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AN EVALUATION OF MEDIUM-SMALL SCALE NATURAL COLOR AND COLOR INFRARED PHOTOGRAPHY AND MEDIUM SCALE BLACK AND WHITE INFRARED FOR THE IDENTIFICATION OF SELECTED FOREST RESOURCE FEATURES

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled 'An Evaluation of Medium-small Scale Natural Color and Color Infrared Photography and Medium Scale Black and White Infrared for the Identification of Selected Forest Resource Features' submitted by Robert Morton in partial fulfilment of the requirements for the degree of Master of Science in Forest Science.

Abstract

This project was undertaken to evaluate the suitability of medium scale black and white infrared and both natural color and color infrared photography at three medium-small scales for the identification of selected resource characteristics and qualities. Resource features related to forestry, recreation and wildlife habitat were interpreted by a large number of participants having varying levels of experience and color perception. Test areas were chosen to represent the boreal, transition/foothills and subalpine forest regions in Alberta. The accuracy of identification and time required for interpretation were evaluated with respect to film type, scale, interpreter inventory experience, photo-interpretation experience and color discrimination ability. Imagery acquisition costs were evaluated.

Identification accuracy of most resource features on natural color and color infrared at scales of 1:30,000, 1:50,000 and 1:70,000 was equivalent to that on 1:15,000 black and white infrared. Field inventory experience, photo-interpretation experience and color perception did not seriously affect accuracy of identification of the features examined. Interpreters preferred either conventional black and white infrared or color infrared at 1:30,000 demonstrating that personal preference may not be a reliable indicator of imagery suitability for interpretation.

Wider use of medium-small scale color photography for inventory may be justified by the identification accuracy attained, and the appreciable reduction in imagery acquisition cost when compared with the medium scale black and white infrared photography.

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Table of Contents

List of Tables

List of Figures and Plates

1. Introduction

Forest land managers have long recognized the advantages of using aerial photographs for inventory (Andrews and Trorey 1933, Losee 1942, Stone 1950, Flowers 1980). Currently, medium scale 1:15,000 black and white infrared photography is used for forest cover interpretation in Alberta (Lowe 1980). Various film types and scales have been suggested as suitable alternatives (Colwell 1978a). Due to the availability of this photography and the high costs incurred in the acquisition of alternate imagery, other resource analysts have accepted this black and white infrared for their own purposes.

Although most integrated resource inventories commonly "share" aerial imagery due to cost restrictions (Aldrich 1979b), it is questionable whether a single film and scale best serves the needs of a range of resource disciplines (Fraser 1980). Resolution requirements vary by the type and size of feature. Fontaine (1973) suggests that suitable scale selection is dependent not only on the criteria used for stratification within each discipline, but the refinement of the stratification itself.

1.1 Problem Statement and Research Objectives

Increasing emphasis is being placed on multiple resource use. To accommodate this, inventory efforts between resource disciplines must be coordinated. Inventory design

should enable efficient collection of the required data (Aldred 1980). New cost-effective techniques provide alternatives for the acquisition of this information (Sayn-Wittgenstein 1980). Yet many foresters and other resource analysts in Alberta are uncertain which combinations of film types and scales will best meet their needs.

The general problem may be summarized as follows:

For the identification of selected resource features, what are the relationships between accuracy and cost and 1) film type, 2) scale, and 3) interpreter experience/color ability group?

The study described here addressed this problem as it relates to the identification of selected resource features in Alberta. Specifications for the identification of forest stands, potential recreation sites and wildlife habitat sites were based on operational inventory procedures of Alberta Energy and Natural Resources.

The objective of this project was to evaluate the use of natural color and color infrared aerial photography at three medium-small scales for the identification of selected forest resource features as possible alternatives to the large to medium scale black and white infrared photography currently used in Alberta by:

1. Evaluating the effects of film type and scale on the accuracy of photo-interpretation by experienced foresters, recreation inventory personnel and wildlife habitat biologists.
2. Examining the cost effectiveness of this imagery for the identification of selected forest characteristics and qualities.

1.2 Imagery Selection

Choice of imagery for this study was limited by the availability of high altitude aircraft and the number of cameras operating. Natural color (Kodak Aerocolor 2445 Negative) and color infrared (Kodak Aerochrome 2443 Reversal) films, at three scales (approximately 1:30,000; 1:50,000; 1:70,000) were acquired over three study sites. A brief discussion of these choices follows.

1.2.1 Film Type

Numerous studies support the use of color films for the description of timber resources, wildlife habitat and recreation sites on forest land. Color, formed through the interaction of hue (principal color), value (luminosity), and chroma (saturation) (Levine 1969, Padgham 1975) increases the information content of a photograph (Anson 1970). An average observer may only be able to separate 200 shades of gray (Parry, Cowan and Heginbottom 1969a) while

discriminating up to five million separate colors (Slater 1975). Taking advantage of this, Cooper and Smith (1966) suggest that the detection of ground conditions may be more easily interpreted on color than on black and white imagery. Reeves (1969) expects "increased visual acuity" with the use of color: Watson and Van Ryswyk (1980) concur that color is the critical element in photo-interpretation. The use of color photography has been employed in the interpretation of terrain conditions (Gimbarzevsky 1972), rangeland (Nosseir 1974, Watson 1977, Watson and Van Ryswyk 1980), wetlands (Anderson 1969, Anderson 1973, Avery 1977, Gammon 1979), watershed characteristics (MacConnell and Niedzwiedz 1979, Rango 1975) and forest damage (Ciesla 1974, Flowers 1980, Meyer and French 1967, Wert and Roettgering 1968).

Color becomes particularly important as an interpretative aid when scale decreases (Sayn-Wittgenstein 1978). The interpreter must increasingly rely on the key characteristics of image tone or color, texture and associations, which are indirect expressions of ground conditions. The question is, which film/scale combination can provide enough information to allow interpreters to identify site features?

Natural color emulsions offer several advantages to the resource analyst. Sensitive to visible light, color films provide reproductions that are similar to the original scene, having familiar shadings of hues and saturations (Sorem 1967). As a result, inexperienced interpreters can

quickly become accustomed to its use (Cooper and Smith 1966). The natural appearance on large scale natural color imagery provides "....specific color signatures for many species, a greater amount of information on the canopy texture in general, and the morphological characteristics of the tree crown in particular" (Parry, Cowan and Heginbottom 1969b). More accurate species identification is possible (Aldrich 1966) with a reduction in time taken for interpretation (Hostrop and Kawaguchi 1971) and correspondingly less time required for field checking.

Disadvantages of color films include higher costs, lower availability, more complex processing and narrower exposure requirements than black and white (Duddek 1967; Haack 1962). Color negative, rather than positive reversal film, is usually specified due to its high resolution (Heller 1971), its more forgiving nature in exposure latitude (Sayn-Wittgenstein 1978) and the ability to control color balance in printing (Sorem 1967).

The sensitivity of color infrared film, coupled with a minus blue filter (Wratten 12), extends from approximately 500 to 900 nanometers i.e. from the green through to a portion of the reflective infrared (Heller 1970). Recent investigations suggest that this may be used to advantage in the identification of terrain characteristics (Lintz and Simonett 1976). Cosgriffe, Linne and Meyer (1973) note that color infrared simplifies interpretation due to enhanced discrimination of resource features. This has been

substantiated in the mapping of ecosystem boundaries (Aldrich 1971a), the interpretation of drainage and soils (Anson 1966) and especially in the description of vegetation. Numerous studies attest to the advantages of color infrared for vegetation analysis (Fritz 1967, Howland 1980, Parker 1978, Thompson 1975, Lauer 1971, Gammon 1979, Malmgren and Garn 1975). Species identification is enhanced (Jaques 1976, Thorley 1975) and stand delineation is more easily accomplished than on black and white photography (Cox, Baxter and Weber 1975). In addition, at high altitudes atmospheric scattering of light has less effect on color infrared as haze is eliminated by the minus blue filter (Heller 1971, Sayn-Wittgenstein 1978). Disadvantages of color infrared include higher material and handling costs, more stringent exposure requirements due to shadow effects, and an unfamiliar "false" color image to which an interpreter must become accustomed. A shift toward the blue-green is evident in the hue of imaged features at higher altitudes (Hansen 1974).

1.2.2 Scale

The selection of scale cannot be made independently of film. Preference is to the smallest, most economical scale that will provide the required amount of detail (Zsilinszky 1964). The use of medium scale (1:10,000 to 1:24,000) for forest inventory has gained wide acceptance (Spurr and Brown 1946, Zsilinszky 1964, Heller 1971, Fontaine 1973).

Interpreters schooled and experienced in the use of this scale are naturally reluctant to accept smaller scale photography. Marshall and Meyer (1978) report that experienced foresters consider scales smaller than 1:24,000 unacceptable for standard data collection. Personal opinions expressed locally suggested that the ability to discriminate characteristics such as species, crown cover, vegetation height and site conditions suffers with decreased scale.

Small scale photography has commonly been recommended for regional appraisals and reconnaissance surveys (Aldrich and Greentree 1977, Douglass and Meyer 1973, Fontaine 1973, Howard 1970, Stellingwerf 1969, Wilson 1967). Although key parameters for interpretation vary by scale (Sayn-Wittgenstein 1960), sufficient detail may exist on small scale photos for the accurate identification of landforms (Aldrich 1979a) and forest stand conditions (Thorley 1975, Heller 1971, Stellingwerf 1971, Harris 1972, Nielsen and Wightman 1971). Hegg (1978) reports that 1:110,000 color infrared photography acquired for the Porcupine National Forest in Alaska had more potential for multiresource inventory than conventional black and white photography. Advantages of greater synoptic view (Keene and Pearcy 1973, Ulliman 1975, Wilson 1967), fewer photos to handle during data transfer (Dempster and Scott 1979) and subsequent cost savings (Aldrich 1966, Lauer and Benson 1973, Kirby and van Eck 1979) support further evaluation of a range of medium-small scale imagery.

1.3 Interpreters

There are numerous human effects which may affect photo-interpretation. Stereoscopic perception and visual acuity (Colwell 1981), imagination, patience, judgement, learning capacity, education and motivation (Avery 1965) and regional knowledge (Howard 1970) may all contribute in varying degrees. In particular, the relationship between experience and accuracy of interpretation is obscure. Photo-interpretation experience may have a positive effect (Leachtenauer 1973, Valentine 1978) or no influence on accuracy (Seher and Tueller 1973). Field experience may be more important (Draeger and Carneggie 1974). Color discrimination is considered as another personal factor due to the high occurence of abnormal (defective) color perception in the population (Padgham and Saunders 1975, Blackwell 1979).

Participants were selected on the basis of practical experience in the resource disciplines of forest inventory, wildlife habitat and recreation inventory, and included seventeen forestry interpreters from the Phase III forest inventory section of the Resource Evaluation and Planning Division, seven wildlife habitat biologists and twelve Alberta Parks and Recreation site inventory personnel.

Three "human" factors were recognized as potentially contributing to interpreter performance. These included:

1. Field inventory experience,
2. Photo-interpretation experience,

3. Color discrimination ability.

Interpreter groups were arbitrarily defined as:

1. Field experience:

   Group 1: 0 to 6 months

   Group 2: 6 to 24 months

   Group 3: more than 24 months

2. Photo-interpretation experience:

   Group 1: 0 to 6 months

   Group 2: 6 to 24 months

   Group 3: more than 24 months

3. Color discrimination score:

   Group 1: 0 to 39 (good)

   Group 2: 40 to 68 (moderate)

   Group 3: more than 69 (poor)

Grouping by color discrimination was based solely on total error score and did not consider individual color confusion zones.

1.4 Costs

The selection of suitable imagery for photo-interpretation is a function of identification performance as well as time required for photo-interpretation and the material and flying cost of imagery acquisition. Increased accuracy in stratification and terrain feature identification reduces the amount of field work required for verification, a more significant

cost than imagery acquisition (Wert and Roettgering 1968, Stellingwerf 1969). In an analysis of imagery cost and efficiency, Nieuwenhuis (1975) concluded that acquisition cost should not be the decisive factor in selection since the cost of photography and interpretation was a small proportion of total mapping and inventory costs. Nevertheless the fixed and variable costs (Paterson 1971) encountered in this project deserve examination.

There is evidence in the literature that photo-interpreters exhibit less hesitation and make more certain identification of resource features on natural color and color infrared than on conventional black and white infrared photography (Arneson and Bradley 1969, Lintz and Simonett 1976). Leachtenauer (1973) observed no relation between accuracy and time. Management considerations, especially relating to conducting an operational inventory, justify the assessment of the time required for identification of selected resource features on the acquired imagery.

1.5 Approach to the Problem

This project was undertaken to evaluate the performance of large scale black and white infrared and both natural color and color infrared at three small scales for the identification of selected resource characteristics. Resource characteristics related to forestry, recreation and

wildlife habitat were interpreted by a large number of participants having varying levels of experience and color perception. Test areas were chosen to represent the boreal, transition/foothills and subalpine forest regions in Alberta and sample locations were selected at random. Natural color and color infrared at three scales was flown by the Canada Center for Remote Sensing on the same day for each test area. Ground control for each sample site within each area was established and provided the basis for measuring interpretation accuracy. This allowed the effects of film, scale interpreter experience and color discrimination ability on identification accuracy and cost to be examined under carefully controlled conditions.

2. Experimental Methods

Experimental layout allowed direct and simple comparisons between the combinations of film type, scale, and interpreter group on the accuracy and cost of photo-interpretation. A large group of practicing foresters, biologists and recreationists identified resource features of importance for inventory and assessment in their disciplines.

2.1 Hypotheses

This experiment was essentially an exercise in identification. Although a number of resource disciplines were included, and the site features (variables) were different, the basic hypotheses formulated were:

1. Interpretation accuracy/time is not related to film type.
2. Interpretation accuracy/time is not related to scale.
3. Interpretation accuracy/time is not related to interpreter:
    a. Field inventory experience.
    b. Photo interpretation experience.
    c. Color discrimination ability.
4. Interpretation accuracy/time is not related to film type/scale combinations, including black and white infrared imagery.

2.2 Experimental Design

Two experimental models were used to test the four hypotheses for each resource characteristic. A controlled four factor experiment allowed testing the effects of the treatments on interpretation accuracy. Treatments included block, film type, scale and interpreter group. In this fixed effects model the factors were as follows:

1. Block: Boreal, Foothills, Subalpine regions.
2. Film: 2 levels (color and color infrared)
3. Scale: 3 levels (1:30,000, 1:50,000, 1:70,000)
4. Interpreter Group: 3 levels (good, medium fair) based on:
   a. field inventory experience in the discipline,
   b. general photo interpretation experience,
   c. color discrimination ability.

Assignment of individual interpreter experience/ability classes is summarized in Table 1.

Table 1: Number of Interpreters Assigned to Groups

Factor	Group 1	Group 2	Group 3
Experience	0-6 months	6-24 months	24 plus months
A. Inventory			
Forestry	4	6	7
Recreation	3	3	6
Wildlife	-	-	-
B. Photo-interpretation			
Forestry	12	1	4
Recreation	4	4	4
Wildlife	4	1	2
C. Color Discrimination			
	Good 0-39	Medium 40-68	Poor 69 plus
Forestry	7	5	5
Recreation	4	5	3
Wildlife	4	3	-

To test for differences in the identification accuracy and cost for the six film type and scale combinations above, and standard black and white infrared, each combination of film type and scale was assigned as a treatment in a randomized block experiment. One observation for each treatment and block was made and a two-way nonparametrics procedure (Quade Test, Conover 1980) was used for testing the hypotheses.

2.3 Resource Characteristics and Qualities

Selection of the resource characteristics and qualities to be identified by the interpreters was based on a literature review, consultations with resource analysts from Alberta Energy and Natural Resources and an evaluation of current inventory specifications. Resource characteristics were limited to those features of importance for management planning in forestry, wildlife and recreation applications which could be interpreted through direct recognition or the assimilation of indirect visual clues. The whole range of resource characteristics and qualities was not tested for each film/scale combination therefore comparisons by feature were not made.

2.3.1 Forestry

Forest inventory provides basic information on vegetation distribution, species types and associations, density, height, growth and yield (Colwell 1971b). These data are fundamental to timber management and silvicultural planning. Currently in Alberta, the Phase III Forest Inventory is being undertaken by the Resource Evaluation and Planning Division of Alberta Energy and Natural Resources. This "management inventory" provides detailed 1:15,000 type maps with volume estimates assigned to each cover type (Lowe 1980). Forest land is stratified into non-productive land (water, muskeg, scrub, barren) and productive forest (land capable of producing 50 plus cubic meters per hectare gross

roundwood volume all species at 120 years) delineated by specified minimum size area. Stocked productive forest (areas with greater than six percent commercial species crown cover) is further described by crown density, height class, species composition, commercialism, age (origin), relative site index and applicable site conditions of understory, slope and disturbance (Table 2). Average stand age was provided to the interpreters for the estimation of site index. Interpreter observations were recorded in the following form:

C 3 SwA(P) - L - M

where:

"C" is the density class.

"3" is the height class.

"SwA(P)" is the species composition.

"L" is the commercialism class.

"M" is the site index.

Table 2: Forestry Interpretation Specifications

Variable	Class	Description
Density	A	6-30% crown density
	B	31-50%
	C	51-70%
	D	71-100%
Height	0	0.0- 6.0 meters
	1	6.1-12.0
	2	12.1-18.0
	3	18.1-24.0
	4	24.1-30.0
	5	30.1+
Species	Sw	White spruce
	Sb	Black spruce
	P	Pine
	Fb	Balsam Fir
	Fd	Douglas Fir
	Fa	Alpine Fir
	Lt	Larch
	A	Aspen or other deciduous
Commercialism	L	Lumber: Miniumum 50 cubic meters per hectare gross coniferous sawlog unless 40% plus merchantable stems are of roundwood size.
	R	Roundwood: 50 cubic meters per hectare gross coniferous
	H	High Uncommercial: 50 cubic meters per hectare gross all species
	U	Low Uncommercial: less than 50 cubic meters per hectare gross all species
Site (70 years)	G	Good: 20 plus meters White spruce, Pine and aspen; 12 plus meters Black spruce.
	M	Medium: 15-20 meters White spruce, Pine, Aspen; 9-12 meters Black spruce.
	F	Fair: less than 15 meters and 9 meters respectively.

Species content in percent are listed in decreasing order of gross roundwood volumes (stands over 12 meters) or crown cover (stands less than 12 meters). Species up to 10 percent are included with similar species to increase their ranking. Three species of 20 percent content are recognized plus one of 11 to 20 percent indicated in brackets. Tree merchantability limits are described:

1. Unmerchantable stem: less than 12.4 centimeters DBH.
2. Merchantable non-sawlog: 12.4 to 17.7 centimeters DBH.
3. Merchanatable sawlog: 17.8 plus centimeters DBH.

Site index tables were provided to the interpreter listing site (reference age 70 years) by 6 meter and 10 year age classes.

2.3.2 Wildlife

Biologists require data on the arrangement and dispersal of food, water and shelter (Rodiek and McCarthyl 1978). Specifically, habitat analysis requires information on the height and species composition, types of water resources and wetlands, and the cover and regeneration conditions of logged and burned forest areas (Fraser 1980).

Specifications for the wildlife habitat interpretation included habitat type, species, vegetation height, slope, aspect, and site condition (Table 3). The photo-interpretation code sheet was compiled by Ms. Beth McCallum of the Wildlife Habitat Section, Department of Energy and Natural Resources. Interpreter observations were

in the following form:

08A2123

where:

" 08 " refers to the habitat type

" A " refers to the species code

" 2 " refers to the vegetation height

" 1 " refers to the slope

" 2 " refers to the aspect

" 3 " refers to the site condition

Table 3: Wildlife Habitat Interpretation Specifications

Variable	Class	Description
Habitat Type	01	Grass meadow: 70 percent plus grass
	02	Mixed meadow: 50 percent plus grass
	03	Mixed meadow: 50 percent plus shrub
	04	Shrub meadow: 70 percent plus shrub
	05	Sedge meadow
	06	Open muskeg
	07	Treed muskeg
	08	Deciduous: 70 percent plus deciduous
	09	Mixed wood: 50 percent plus deciduous
	10	Mixed wood: 50 percent plus coniferous
	11	Coniferous: 70 percent plus coniferous
Species	W	Willow
	B	Dwarf Birch
	O	Other shrub
	Sw	White spruce
	Sb	Black spruce
	P	Lodgepole pine
	Fb	Balsam and alpine fir
	Fd	Douglas fir
	Lt	Larch
	A	Deciduous
Height	0	0.0 to 0.3 meters (grass)
	1	0.3 to 2.0 meters
	2	2.1 to 6.0 meters
	3	6.1 plus meters
Slope	1	Less than 30 degrees (57.7 percent)
	2	Greater than 30 degrees
Aspect	1	West, southwest, south
	2	Bottomland
	3	Other slope
Site Condition	0	Improved
	1	Overused
	2	Wet
	3	Dry
	4	Cutover
	5	Disturbed

2.3.3 Recreation

Recreational opportunities depend on the variety and distribution of landforms and vegetation cover on a site (Olson, Tombaugh and Davis 1969). Essential considerations in site selection for further development are:

1. Accessiblity.
2. Availability of water.
3. Suitability of the terrain (Dill 1963).

A recreation inventory manual, compiled by the Resource Assessment and Management Section, Outdoor Recreaton Planning Branch, Alberta Provincial Parks (prepared by G. More and S. Loomis) provided the criteria and classification for interpretation. Completed site inventories indicate "....prime potential sites for candidate review for development." The most important variables were extracted from these specifications, describing the biophysical and water body characteristics of the site. For comparative purposes, two subjective estimates of site attractiveness and capability for camping were included. Interpreter observations were in an eight column format with the following interpretation:

Column 1: Topography
Column 2: Crown Type
Column 3: Water Type
Column 4: Water Depth
Column 5: Shoreline Stability
Column 6: Backshore Drainage
Column 7: Attractiveness
Column 8: Capability for Camping

Refer to Table 4 for the site description specifications.

Table 4: Recreation Site Interpretation Specifications

Variable	Class	Description
Topography	1	Flat
	2	Gently rolling
	3	Hilly
	4	Rugged
Crown Type	1	Deciduous
	2	Coniferous
	3	Mixed deciduous with minimum 25 percent coniferous.
	4	Mixed coniferous with minimum 25 percent deciduous.
	5	No crown cover
Water Type	1	Lake
	2	Reservoir
	3	Pond/slough
	4	Wetland
	5	Stream/river
	6	Spring
Water Depth	1	Standing: less than 2 meters
	2	Standing: more than 2 meters
	3	Flowing: Shallow: 0.0 to 0.3 meters
	4	Flowing: Low: 0.3 to 1.0 meters
	5	Flowing: Deep: more than 1.0 meters
Shoreline Stability	1	Stable
	2	Unstable
	3	Active
Backshore Drainage	1	Well
	2	Moderate
	3	Poor
Attractiveness	1-10	Low to high estimate
Capability for Camping	1-10	Low to high estimate

2.4 Study Areas

Three test sites were selected within the Green Zone of Alberta, representing the major forest regions (boreal, transition and subalpine) encountered in the province (Rowe 1972). In consultation with officials of the Resource Evaluation and Planning Division of Alberta Energy and Natural Resources, these areas were chosen to insure reasonable access, minimum distance between test areas, and for the availability of completed Phase III interpretation. Locations of the study areas are shown in Figure 1. Area 1 (Two Creek) is situated 70 kilometers north-west of Whitecourt, Alberta (Township 61, Ranges 15 and 16 west of the Fifth Meridian). Characteristic tree species within this flat to rolling boreal region are white spruce (*Picea glauca* (Moench) Voss.), black spruce (*Picea mariana* (Mill.) B.S.P.), lodgepole pine (*Pinus contorta* Dougl. var. latifolia Engelm.), trembling aspen (*Populus tremuloides* Michx.) and larch (*Larix laricina* (Du Roi) K.Koch). Area 2 (Cache Percotte) lies immediately east of the Hinton, Alberta townsite (Township 51, Ranges 24 and 25 west of the Fifth Meridian). Common species within this lower foothills transition zone are lodgepole pine, trembling aspen, balsam poplar (*Populus balsamifera* L.), white spruce, and black spruce occuring in mixed wood stands over rolling topography. Area 3 (Wildhay River) lies within the eastern slopes subalpine zone (Rowe, 1972) 80 kilometers north-west of Hinton (Township 52, Ranges 1 and 2 west of the Sixth

Meridian). It is characterized by large tracts of pure conifer stands inhabiting valley outwash areas. Characteristic species are engelmann spruce (*Picea engelmannii* Parry), alpine fir (*Abies lasiocarpa* (Hook.)Nutt.), lodgepole pine, trembling aspen, and black spruce.

Figure 1: Study Area Location

2.5 Acquisition of the Aerial Photography

A commercially available range of scales were selected for evaluation. Limiting the smallest scale (1:70,000) acquired were:

1. The operational ceiling of the aircraft (10,700 meters above sea level).
2. The specified focal length of 15.2 centimeters.

The largest scale (1:30,000) was assumed to be the limit at which the increased cost of color imagery could be justified. It was recognized that at lower altitudes conventional scale black and white infrared, with high spatial resolution, provides sufficient information for the identification of overstory characteristics and some terrain conditions. Introduction of a color element in photo-interpretation was considered unnecessary and possibly confusing. The 1:50,000 was chosen as an appropriate interval between the largest and smallest scales due to Simpson Timber Company (Alberta) Limited's success with color infrared at this scale (Dempster and Scott 1979).

Natural color and color infrared photography was flown over the three test sites on September 14, 1979 by the Canada Center for Remote Sensing [1]. It was difficult to

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[1]Forest cover interpretation is commonly undertaken on photos flown during mid-summer when there are leaf-out conditions, the weather is generally good, and when the sun angle is optimum (Sayn-Wittgenstein 1971). This convention was accepted although Douglass and Meyer (1973) suggest that season of photography has an influence on the identification accuracy of forest types. Late leaf flush prevented flying earlier than July. Five attempts during July and August were unsuccessful due to heavy haze conditions.

obtain satisfactory small scale photography during the summer of 1979 due to heavy atmospheric haze conditions. These conditions resulted in lower luminance, obscured detail, poor color fidelity and a color shift on the imagery, effects previously noted by Duddek (1971), Tarkington and Sorem (1963) and Hansen (1974)in the acquisition of color imagery. Conventional black and white infrared photography in positive print form for each area was obtained from the Resource Evaluation and Planning Division, Alberta Energy and Natural Resources. Acquisition dates for this imagery differed by area. Two Creek (Area 1) was flown in 1978, Cache Percotte (Area 2) in 1979 and Wildhay River (Area 3) in 1974. Scales acquired over each test site are listed in the following table. The color photography was processed to positive prints for field use and to positive transparencies for actual interpretation.

Table 5: Average Photo Scales Acquired by Film and Area

Film Type	Area 1	Area 2	Area 3
Natural Color and Color Infrared	1:29,400	1:27,800	1:26,800
Natural Color and Color Infrared	1:54,560	1:54,000	1:52,100
Natural Color and Color Infrared	1:67,500	1:65,600	1:64,900
Black and White Infrared	1:15,000	1:15,000	1:21,000

2.6 Sample Site Selection

Within each of the three blocks (forest regions), two sample sites were independently assigned to each of the seven film/scale combinations. Forest stands were selected from stocked productive forest land (Lowe 1980). Within each film/scale flight line a grid was overlaid on a random frame. Random coordinates on the grid falling within the effective area of the photo identified two individual stands for interpretation. Random replacement stands of the same species composition were substituted for inaccessible stands [2]. Wildlife habitat test sites of five to ten hectares were subjectively located in accessible unstocked productive and unproductive forest areas based on accessibility. These sites were grouped in closest pairs and assigned at random to each film/scale combination. Recreation sites of five to ten hectares were selected on the basis of reasonable vehicle access and the availability of water as specified by More and Loomis (1980). Nearest pairs were grouped and assigned at random to the individual film/scales combinations.

Once located, all sites were delineated on the photos to ensure identical boundary location for interpretation. Example sites are illustrated on Plates 1 through 5 (Appendix A) on natural color and color infrared photos over the three forest blocks.

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[2] A forest stand was judged inaccessible when more than one man/day was required to reach and inventory it on foot.

2.7 Photo Interpretation Procedure

Interpretation sessions were conducted at the Alberta Remote Sensing Center. Prior to the interpretation sessions, the participants were introduced to the objectives and scope of the project in a short seminar. Basic instruction on the fundamentals of color and color infrared films and their interpretation was given. A set of "training" photos, illustrating example site interpretations on various film/scale combinations, was left with the group for inspection prior to the interpretation session.

On arrival at the Remote Sensing Center, participants were screened by completing an Ishihara Pseudoisochromatic Color Blindness Test which indicated that no interpreters were conclusively red-green deficient. This was followed by the Farnsworth-Munsell 100 Hue Test [3] and instruction on the operation of the Interpretscope. Starting with a randomly chosen block, the film/scale combinations were presented to the interpreter in random order. In contrast to imagery evaluations by Ashley, Rea and Wright (1976) and Ulliman and French (1977), interpreters viewed sites only once. Relevant information regarding film type and scale, geographical location and direction of view was provided. Average stand age was given for forest stand interpretation. Times were

[3] Pseudoisochromatic charts test the observer's ability to distinguish mixtures of reflected monochromatic wavelengths (Padgham and Saunders, 1975). The Farnsworth-Munsell 100 Hue Test provides a measure of interpreter color discrimination and indicates the location of color confusion zones. The procedure is described in the test manual (Revised 1957 by D. Farnsworth, Munsell Color Company Limited).

recorded once the interpreter was comfortably in stereo, was oriented and had been shown the sample sites. Recorded time excluded time for instrument instruction, sample site delineation, photo-handling and stereo set-up. After inspecting the photo at his leisure, he gave his interpretation.

On completion of the interpretation, the participant completed the 100 Hue Test once more, then filled out a questionnaire indicating personal experience levels and imagery preferences.

2.8 Field Survey Methods

The purpose of the field survey was to establish ground control for each sample site interpreted on the aerial photography. Survey intensity reflected the requirement for feature identification, rather than indepth site evaluation and inventory. Recreation and wildlife habitat sites were described during a field inspection. Experienced personnel assisted to ensure realistic site descriptions. A professional wildlife biologist visited all habitat sites, and a recreation inventory technician inspected six recreation sites to evaluate the author's observations (and provide a means of calibration). Forest stand descriptions were based on a summary of measured site characteristics (Phase III inventory specifications were used) with the exception of stand density. Accepted control for this

variable were values extracted from unpublished Phase III interpretation maps. Ten point samples were located systematically along the main axis of each delineated stand[4]. Trees were tallied by species and diameter class. Heights were taken of four dominant/codominant trees closest to the plot center. One age (stump height) was taken of a sample tree falling within the dominant basal area species group.

Average stand height was established from the 40 height observations in each stand. Species composition was described by decreasing basal area by species from the summary of the ten sample plots. Commercialism was calculated from the conversion of basal area to volume as described in the Phase III inventory specifications (Lowe 1980). Site was estimated using Alberta Forest Service site index curves.

2.9 Analysis Procedures

Session observations were compiled in matrices by test site within each film/scale/block and interpreter combination. Accuracy was defined as the degree to which the interpreters agreed with the ground observations (Valentine 1978) over a number of attempts. Each cell within each observation was compared directly to the accepted field

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[4] A random start was taken from the stand boundary selected from the interval estimated to accomodate 10 plots spaced along the stand length.

survey description and assigned a value of 1 if it successfully duplicated it, and 0 if it did not. Calculation of percent correct was based on the success of two trials (replications) per film/scale/block combination by interpreter resulting in one of three possible responses: 0, 50 or 100. This measure of accuracy formed the foundation for the construction of confusion matrices and the arrangement of experience and color discrimination groups. Colwell (1971a) defines the overall rating of interpretability as the total percent correct identification for all categories. Relative rankings were considered more important than absolute values due to interpreter inexperience with the color and the effects of the test administration. All analyses were conducted at the experimental significance level of 95 percent (Colwell 1978, Levine 1969).

Grouping by experience was based on questionnaire returns which indicated only general inventory and photo-interpretation experience, not specific familiarity with particular areas or film/scale types. The color discrimination score was the average total score, over two trials, of the Farnsworth-Munsell 100 Hue Test. Limits on the discrimination groups did not correspond to the overall ability classes described by Farnsworth (1957) but were defined to separate approximately equal numbers of interpreters within each group for analysis. Low error scores (Group 1) indicated high to superior color

discrimination ability, while higher scores indicated increasing color confusion. Assignment of individual interpreter experience and ability groups is summarized in Table 1.

Analysis and hypothesis tests were based on treating the data as four separate experiments. The first three follow the four factor design described in section 2.2 and differ only in the definition of the interpreter group factor:

Experiment 1: Field inventory experience,

Experiment 2: Photo-interpretation experience,

Experiment 3: Color discrimination ability.

Tukey (Steel and Torrie 1960) and Scheffe (Scheffe 1959) multiple comparisons were used to test for significant differences between treatment levels of the three factors within each experiment. Mean square error values for the calculation of significant contrasts were extracted from appropriate analyses of variance.

Experiment 4 tested the hypothesis (4) that there is no difference in interpretation accuracy or interpretation time over the seven different film type and scale combinations. Combinations consisted of six from the interaction of three scales and two films, and one for 1:15,000 black and white infrared. Imagery effect on interpretation was tested using the Quade Chi-Square nonparametric test (Conover 1980) with

a randomized block layout.

Cost effectiveness was approached in two ways. First, the times recorded for the identification of two sample sites per stereo pair by film/scale and area combination were analyzed to determine significant effects. Analysis procedures, consisting of the four separate experiments, were similar with times recorded for each paricipant interpreting the film/scale combinations substituted for the percentage correct data. In addition, costs were calculated for the acquisition of the photography tested for complete stereo coverage of a rectangular block with dimensions 30 by 20 statute miles (48 by 32 kilometers). The Canada Center for Remote Sensing cost recovery program was used to generate basic flight plan data and cost estimates with the following specifications:

1. Camera: Wild RC 10 (23 centimeter format)
2. Focal length: 15.2 centimeters
3. Forward overlap: 60 percent
4. Side overlap: 30 percent
5. Reproduction:
    a. Black and White Infrared: Prints
    b. Color Negative: Positive Transparencies
    c. Color Infrared: Positive Transparencies

2.10 Experimental Controls

Strict control of test procedures and variables is required to minimize confounding experimental effects (Draeger and Carneggie 1974). As an objective evaluation of imagery suitability, a number of standard effects were recognized:

1. The black and white infrared was accepted as representative of standard photography available for Phase III forest cover interpretation.
2. The analysis did not account for variation in quality of the natural color or color infrared photography.
3. The comparison of imagery types applied to the interpretation of black and white infrared prints versus positive transparencies for the color imagery.
4. The study was designed to evaluate differences in the identification accuracy attained on each film/scale combination and not to assess the suitability for identifying any particular feature.
5. The variation in average photo scale by film type between the blocks was considered insignificant.
6. The differences in acquisition dates of the black and white infrared and the color photography was assumed to have an insignificant effect.
7. Participants were assumed to have acceptable stereoscopic perception and visual acuity.
8. It was assumed that participants were competent in their discipline and were familiar with the classification

system used in the test.

9. All interpreters were assumed to have a common minimum experience level with the interpretation of the acquired photography.
10. All photo-interpretation was conducted on the Interpretscope with the optical magnification held constant at three power [5].
11. All treatment combinations were applied at random within each block and all interpreters inspected the same delineated site on each film/scale combination.
12. Film/scale combinations were presented in random order to minimize learning bias.

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[5]Personal preference plays a major role in the selection of optical magnification. Through empirical tests, Aldrich (1979a) recommends the use of two power for 1:32,000, three power for 1:40,000, 3.5 power for 1:64,000 and four power beyond to 1:83,000. Consultations locally confirmed that three power was reasonable.

3. Results and Analysis

Analysis of identification accuracy is described here by resource characteristic and quality in the following order: forestry, recreation and wildlife. Sample site identifications are presented in Appendices B, C and D with individual interpreter observations listed in columns by sample site within each film/scale combination. Ground control descriptions are shown in the first row beneath the header. Identification accuracy (percent correct) is summarized for each sample site and film/scale combination. Treatment effects on imagery performance are reported with reference to the individual experiments outlined in Section 2.2. Following this is an examination of cost-effectiveness, as indicated by time required for interpretation and imagery acquisition costs. Finally, a summary of the interpreter questionnaire results is presented.

Table 6 summarizes the results of the analyses of variance of interpretation accuracy for the color and color infrared films. Statistically significant main effects and interactions are indicated by asterisks. Variance ratio values have not been included. Table 7 presents a summary of imagery performance for each variable based on average percent correct across all interpreters, sites, films and scales. Presented in Table 8 are identification accuracies by film and scale combination ranked in descending order for significant interactions.

TABLE 6. ANALYSES OF VARIANCE FOR COLOR AND COLOR INFRARED PHOTOGRAPHY

VARIABLE	FACTORS A	B	C	D1	D2	D3	BC
FORESTRY							
DENSITY			*				
HEIGHT	*						*
SPECIES CLASS	*		*	*	*	*	*
COMMERCIALISM	*	*					*
SITE			*			*	*
TIME					*	*	
RECREATION							
TOPOGRAPHY			*				*
CROWN TYPE		*					
WATER TYPE	*		*				
WATER DEPTH	*	*					*
SHORELINE STABILITY	*						*
BACKSHORE DRAINAGE							
ATTRACTIVENESS							
CAPABILITY FOR CAMPING							
TIME				*	*	*	
WILDLIFE HABITAT							
HABITAT TYPE							
SPECIES	*						
HEIGHT							
SLOPE							
ASPECT	*						*
SITE CONDITION	*	*	*		*		
TIME	*				*	*	

FACTORS A: BLOCKS(3)
B: FILM TYPES(2)
C: SCALES(3)
D1: INTERPRETER FIELD EXPERIENCE (3 GROUPS)
D2: INTERPRETER PHOTO INTERPRETATION EXPERIENCE (3 GROUPS)
D3: INTERPRETER COLOR DISCRIMINATION TEST SCORE (3 GROUPS)

NOTE: SIGNIFICANCE LEVEL = .95
* INDICATES SIGNIFICANT VARIANCE RATIO

TABLE 7: ACCURACY SCORES BY FILM/SCALE COMBINATION IN PERCENT

FILM TYPE	NATURAL COLOR			COLOR INFRARED			B&W IR
SCALE	1:30,000	1:50,000	1:70,000	1:30,000	1:50,000	1:70,000	1:15,000
FORESTRY							
DENSITY	55.9	57.8	73.5	66.7	59.8	71.6	79.0
HEIGHT	28.4	60.8	53.9	65.7	41.2	57.8	52.0
FIRST SPECIES	77.5	58.8	67.7	79.3	84.3	58.8	58.8
SPECIES CLASS	56.9	42.4	48.0	37.2	64.7	32.3	47.0
COMMERCIALISM	24.5	39.2	49.0	56.9	53.9	49.0	47.0
SITE	38.2	70.6	50.0	55.9	56.8	63.7	28.0
RECREATION							
TOPOGRAPHY	68.1	50.0	40.3	45.8	59.7	50.0	42.0
CROWN TYPE	34.7	48.6	44.4	40.3	25.0	36.1	33.0
WATER TYPE	68.1	81.9	81.9	68.1	88.9	76.4	81.0
WATER DEPTH	58.3	68.1	51.4	54.2	41.7	55.6	42.0
STABILITY	29.2	52.8	47.2	55.6	54.2	37.5	44.0
DRAINAGE	47.2	52.8	52.8	55.6	34.7	58.3	61.2
ATTRACTIVENESS	13.9	19.4	16.7	19.4	18.4	20.8	14.0
CAP. CAMPING	25.0	16.7	12.5	12.5	16.7	22.2	15.0
WILDLIFE HABITAT							
HABITAT TYPE	23.8	19.0	28.6	26.2	33.3	31.0	19.0
SPECIES	33.3	26.2	33.3	35.7	42.9	38.1	35.7
HEIGHT	42.9	50.0	47.6	45.2	52.4	38.1	66.5
SLOPE	85.7	95.2	85.7	83.3	88.1	97.6	100.
ASPECT	57.1	66.7	35.7	52.4	38.1	61.9	54.7
SITE CONDITION	61.9	40.5	47.6	71.4	59.5	61.9	40.5

source: forestry: 102 observations
recreation: 72 observations
wildlife habitat: 42 observations

TABLE 8: INTERPRETATION ACCURACY RANKED BY FILM/SCALE COMBINATION FOR SIGNFICANT INTERACTIONS

FORESTRY

HEIGHT	% CORRECT	TOTAL SPECIES	% CORRECT	COMMERCIALISM	% CORRECT	SITE	% CORRECT
CIR 1:30,000	65.7	CIR 1:50,000	64.7	CIR 1:30,000	56.8	COL 1:50,000	70.6
COL 1:50,000	60.8	COL 1:30,000	56.8	CIR 1:50,000	53.9	CIR 1:70,000	63.7
CIR 1:70,000	57.8	COL 1:70,000	48.0	CIR 1:70,000	49.0	CIR 1:50,000	56.9
COL 1:70,000	53.9	COL 1:50,000	42.2	COL 1:70,000	49.0	CIR 1:30,000	55.9
CIR 1:50,000	41.2	CIR 1:30,000	37.2	COL 1:50,000	39.2	COL 1:70,000	50.0
COL 1:30,000	28.4	CIR 1:70,000	32.4	COL 1:30,000	24.5	COL 1:30,000	38.2

RECREATION

TOPOGRAPHY	% CORRECT	DEPTH	% CORRECT	SHORELINE STABILITY	% CORRECT
COL 1:30,000	68.1	COL 1:50,000	68.1	CIR 1:30,000	55.6
CIR 1:50,000	59.7	COL 1:30,000	58.3	CIR 1:50,000	54.2
CIR 1:70,000	50.0	CIR 1:70,000	55.6	COL 1:50,000	52.8
COL 1:50,000	50.0	CIR 1:30,000	54.2	COL 1:70,000	47.2
CIR 1:30,000	45.8	COL 1:70,000	51.4	CIR 1:70,000	37.5
COL 1:70,000	40.3	CIR 1:50,000	41.7	COL 1:30,000	29.2

WILDLIFE HABITAT

ASPECT	% CORRECT
COL 1:50,000	66.7
CIR 1:70,000	61.9
COL 1:30,000	57.1
CIR 1:30,000	52.4
CIR 1:50,000	38.1
COL 1:70,000	35.7

3.1 Forestry

The overstory components of stand cover (density), height class, species composition, commercialism and site index were described by each of 17 practicing photo-interpreters on 42 sample sites, assigned in pairs to 7 film/scale combinations in 3 areas. Following are the results of the parametric and nonparametric analyses.

3.1.1 Density

Interpretation of density was significantly more accurate on the 1:70,000 scale than the 1:50,000 scale, averaged over the color films and all sets of interpreter groups. Significant contrasts are indicated in Table 9.

Table 9: Tukey Multiple Comparison of Crown Density Identification Accuracy Related to Scale

Scale	Percent Correct
1:70,000	72.5
1:30,000	61.3
1:50,000	58.8

No differences in density interpretation accuracy were detected by film type over any interpreter group, nor was accuracy related to interpreter inventory experience (experiment 1), photo-interpretation experience (experiment 2), or color discrimination ability (experiment 3). Experiment 4 indicated no significant differences in

accuracy between the seven film/scale combinations.

3.1.2 Height

Experiments 1 to 3 indicated that the interpretation of height was not significantly affected by color film type, scale nor interpreter inventory experience, photo-interpretation experience or color discrimination ability. Accuracy of height class estimation was found significantly different with the interaction of film and scale . Each film/scale combination was ranked by interpretation accuracy (Table 8).

Experiment 4 indicated no significant differences in interpretation accuracy related to the seven film/scale combinations disregarding interpreter experience/ability groups.

3.1.2.1 Supplementary Analysis

Considered also for accuracy of height were the actual class limits of the stands sampled. To compensate for the arbitrary limits on the height classes, 95 percent confidence limits were calculated around the mean stand heights and borderline cases, where stand height intervals crossed the class boundaries, were accepted as correct. Therefore, two classes were considered correct when the 95% confidence interval crossed the class border. Few stand classes were adjusted as narrow confidence intervals were established due to 1) limited variation in heights within

the delineated types and 2) intensive field sampling. Adjusted rankings of interpretation accuracy for each film/scale combination are shown in Table 10. Although percentage correct increased, relative rankings for each film/scale combination remained similiar to those presented in Table 8.

Table 10: Adjusted Identification Accuracy for Stand Height Class

Film/Scale	Percent Correct
CIR 1:30,000	76.5
CIR 1:70,000	67.6
COL 1:70,000	67.0
COL 1:50,000	67.0
COL 1:30,000	54.9
CIR 1:50,000	44.0
B&W IR 1:15,000	63.7

3.1.3 Species Composition

Analysis of species description was simplified by eliminating third or bracketed species and grouping observations by species class and primary species.

3.1.3.1 Species Class

Interpreter observations of species composition were assessed by grouping their estimates into eight species classes important in timber management planning. These were:

CP: Conifer: Lodgepole pine dominant
CSw: Conifer: White spruce dominant
CSb: Conifer: Black spruce dominant
H: Pure deciduous
MP: Mixed wood: Lodgepole pine dominant
MSw: Mixed wood: White spruce dominant
MSb: Mixed wood: Black spruce dominant
MA: Mixed wood: Deciduous dominant

Identification of species composition was related to the main effect of scale averaged over both natural color and color infrared films and all interpreter experience/ability groups. Interpretation accuracy scores obtained on the 1:50,000 scale photography (53.4 percent correct) were significantly better than on the 1:70,000 (40.2 percent) (Table 11). Film/scale interaction also affected interpretation: a summary of imagery performance by film/scale combination is presented in Table 8.

Interpreter field inventory experience had a positive influence on identification accuracy with participants having 24 or more months performing better than those with less than six months experience (Table 11). Main effects of photo-interpretation experience (experiment 2) were found significant, however no contrast of interest was significantly different. Color discrimination ability (experiment 3) affected interpretation accuracy with participants exhibiting moderate color error scores (Group 2) performing better than those with more errors. A summary of interpretation performance by interpreter color discrimination ability group is presented in Table 11.

No differences were observed between the seven film/scale combinations analyzed in experiment 4.

Table 11: Multiple Comparisons for Species Class Composition Natural Color and Color Infrared Imagery

Test Used: Tukey- Scale
Scheffe- Inventory Experience
- Photo Experience
- Color Discrimination

Scale	Percent Correct
1:50,000	53.4
1:30,000	47.1
1:70,000	40.2

Inventory Experience	Percent Correct
Group 1	41.0
Group 2	43.0
Group 3	54.0

Photo Experience	Percent Correct
Group 1	43.5
Group 2	55.6
Group 3	55.0

Color Discrimination	Percent Correct
Group 2	52.0
Group 1	49.0
Group 3	38.0

3.1.3.2 Primary Species Identification

To simplify accuracy evaluations, four primary species types were recognized. The first species identified by the interpreter was compared directly to the first species described on the ground control data. The four possible choices were:

1. Fir
2. Aspen
3. Spruce
4. Pine

No distinction was made between alpine or balsam fir, white, black or Engelmann spruce, aspen or other deciduous, or lodgepole and Jack pine. Nonparametric analysis (experiment 4) was used to evaluate the accuracy of interpretation for the seven film/scale combinations. Overall imagery performance increased (Table 12) for all film/scale combinations compared with the stricter identification requirements of part A. However, no significant differences were observed. A further reduction in identification choice into three groups i.e.

a. Conifer
b. Hardwood
c. Mixed Wood

yielded results by film/scale presented in Table 12.

Table 12: Film/Scale Performance for Species Associations

Film/Scale	Percent Correct Primary	Class	Group
Color 1:30,000	77.5	57.0	86.0
1:50,000	58.8	42.0	73.0
1:70,000	67.7	48.0	69.0
CIR 1:30,000	79.3	37.0	56.0
1:50,000	84.3	65.0	75.0
1:70,000	58.8	32.0	64.0
B&W IR1:15,000	58.8	47.0	75.0

Primary Species: First species recorded by the interpreter
Species Class : Combined composition with primary species significant
Species Group : Combined composition: conifer, hardwood or mixed

3.1.4 Commercialism

Accuracy of interpretation was significantly different between natural color and color infrared films. Averaged over scales, blocks and disregarding interpreter experience/color discrimination ability groups, accuracy on natural color was significantly less (37.6 percent) than on color infrared (53.3 percent). Breaking this down further, the interaction of film with scale significantly affected accuracy. Ranked interpretation accuracy by film/scale combination is presented in Table 8. Experiment 4 revealed no differences in identification accuracy between the seven film/scale combinations disregarding interpreter group.

3.1.5 Site

Interpretation performance was equivalent on natural color and color infrared films over all scales and interpreter experience/color discrimination ability groups. Interpretation of site index, averaged over both film types and disregarding interpreter groups, was significantly more accurate on the 1:50,000 scale than on 1:30,000. Level of field inventory experience (experiment 1) or photo-interpretation experience (experiment 2) did not influence site identification accuracy. The main effect of color discrimination ability (experiment 3) was significant, although no contrast of interest was different. Table 13 summarizes the effects of scale and color discrimination ability on the accuracy of identification. Film/scale interactions, disregarding interpreter groups, affected site identification (Table 8).

Table 13: Multiple Comparisons for Site Identification
Natural Color and Color Infrared
Test Used: Tukey- Scale
Scheffe- Color Discrimination

Scale	Percent Correct
1:50,000	63.7
1:70,000	56.9
1:30,000	47.1

Color Group	Percent Correct
1	50.0
2	62.0
3	58.0

Nonparametric analysis (experiment 4) indicated no

significant differences in interpretation accuracy between the seven film/scale combinations.

3.2 Recreation

Interpretation of the 42 sample sites included the identification of six terrain characteristics and two subjective estimates of site quality. The following sections discuss the results of the parametric and nonparametric analyses by variable.

3.2.1 Topography

Interpretation accuracy of topography class was affected by scale and the interaction of scale and film type when analyzed over interpreter inventory experience (experiment 1), photo-interpretation experience (experiment 2) and color discrimination ability (experiment 3) groups. Although no contrast of interest was significant (Tukey multiple comparison), performance by scale is presented in Table 14.

Table 14: Accuracy of Topography Identification by Scale Over Natural Color and Color Infrared Films

Scale	Percent Correct
1:30,000	56.9
1:50,000	54.9
1:70,000	45.2

Accuracy scores of individual film types and scales, disregarding interpreter groups, are presented in in Table 8. Interpretation of topography was not related to interpreter inventory experience (experiment 1), photo-interpretation experience (experiment 2) or color discrimination ability (experiment 3). Experiment 4 indicated that no single film/scale combination was better for identification.

3.2.2 Crown Type

Interpreters were more successful on natural color (42.6% correct) than on color infrared (33.8%) over all scales analyzed by interpreter inventory experience (experiment 1), photo-interpretation experience (experiment 2) and color discrimination (experiment 3) groups. No differences in crown type interpretation were detected for scale , disregarding interpreter group, or between the three levels of inventory experience, photo experience or color discrimination ability groups.

No significant differences in interpretation accuracy were observed between the seven film/scale combinations analyzed in experiment 4.

3.2.3 Water Type

Accuracy of water type recognition was related only to scale. A summary of imagery performance is presented in Table 15.

Table 15: Tukey Multiple Comparison for the Accuracy of Water Type Identification on Natural Color and Color Infrared Photography

Scale	Percent Correct
1:50,000	85.4
1:70,000	79.2
1:30,000	68.1

No differences in the accuracy of water type identification were observed for film type, inventory experience, photo-interpretation experience, or color discrimination groups. Accuracy was equivalent on all film/scale combinations analyzed in experiment 4.

3.2.4 Water Depth

Interpretation of water depth was significantly more accurate on the natural color (59.3%) than the color infrared (50.5%) averaged over all scales and interpreter groups. The main effects of scale or interpreter group did not significantly influence identification accuracy within either experiment 1 (inventory experience), experiment 2 (photo-interpretation experience) or experiment 3 (color discrimination ability). The interaction of film and scale (Table 8) affected accuracy with natural color 1:50,000

(68.1%) performing better than color infrared 1:50,000 (41.7%). No differences in interpretation accuracy were observed between the seven film/scale combinations analyzed in experiment 4.

3.2.5 Shoreline Stability

No differences in stability interpretation accuracy were detected for film types, scales, inventory experience groups, photo-interpretation experience groups or color discrimination groups. Although no differences were observed in the main effects, the interaction of film and scale was significant (Table 8). No differences in accuracy were observed between the seven film/scale combinations analyzed in experiment 4.

3.2.6 Backshore Drainage

Analysis indicated no significant differences in interpretation accuracy related to film, scale, interpreter inventory experience, photo-interpretation experience or color discrimination groups. No differences in identification accuracy were detected between the seven film/scale combinations analyzed in experiment 4.

3.2.7 Site Attractiveness

Analysis indicated no significant differences in interpretation accuracy related to film, scale, interpreter experience or color discrimination ability. No differences

in accuracy were detected between the film/scale treatments of experiment 4.

3.2.8 Capability for Camping

Analysis indicated no significant differences in interpretation accuracy related to film, scale or interpreter group. No differences in accuracy were observed between the three scales of color infrared and natural color or the 1:15,000 black and white infrared examined in experiment 4.

3.3 Wildlife Habitat

Seven wildlife habitat biologists interpreted 42 sample sites, identifying six terrain characteristics on each. The following is a summary of the results.

3.3.1 Habitat Type

Analysis indicated no significant differences in interpretation accuracy related to film, scale, interpreter experience or interpreter color discrimination ability. No differences were observed between the seven film/scale combinations assessed in experiment 4.

3.3.2 Species

Analysis indicated no significant differences in interpretation accuracy related to film, scale or interpreter group. No differences in identification accuracy were found between the seven film/scale combinations analyzed in experiment 4.

3.3.3 Height

Interpretation accuracy of vegetation height was not found related to film, scale, photo-interpretation experience or color discrimination ability. Experiment 4 revealed no differences in identification accuracy related to the seven film/scale combinations disregarding interpreter group.

3.3.4 Slope

Analysis indicated no significant differences in interpretation accuracy related to film, scale, photo-interpretation experience or color discrimination ability. No differences in imagery performance were observed between the seven treatments analyzed in experiment 4.

3.3.5 Aspect

Accuracy of aspect identification was not found related to the main effects of film, scale or interpreter group within experiment 1 (inventory experience), experiment 2 (photo-interpretation experience), or experiment 3 (color

discrimination ability). Although no main effects affected interpretation accuracy, the interaction of film and scale was significant. Imagery performance by film and scale is shown in Table 8 in descending order of interpretation accuracy. Experiment 4 indicated no significant differences in accuracy between the seven film/scale combinations.

3.3.6 Site Condition

Film type and scale significantly affected the accuracy of site condition interpretation within experiments 1, 2 and 3. Site condition identification accuracy was greater on color infrared (64.3 percent correct) than on natural color (50.0 percent). No contrast of interest between scales was significant (source: Tukey Multiple Comparison Test), however performance was generally better on 1:30,000 (66.7 percent) than on the smaller scales of 1:50,000 (50.0 percent) and 1:70,000 (54.7 percent). Photo-interpretation experience significantly affected accuracy of interpretation. Experience with aerial photography demonstrated a positive influence on the accuracy of interpretation. Table 16 summarizes imagery performance related to photo-interpretation experience group averaged over all films, scales and color discrimination groups.

Table 16: Scheffe Multiple Comparison Test of Accuracy of Site Identification by Photo-interpretation Experience Group

Group	Percent Correct
1	52.1
2	52.8
3	69.4

No differences in interpretation accuracy were detected between the two interpreter color discrimination groups (experiment 3). The interaction of film and scale was not significant. Experiment 4 revealed no differences in site interpretation related to the seven film/scale combinations examined.

3.4 Costs

Mean interpretation times by film/scale combination are presented in Table 17. Comparisons with black and white infrared imagery were made using the analysis procedures of Experiment 4 (Section 2.2). Secondly acquisition costs for the aerial photography were calculated for a 1550 square kilometer tract. Costs were compared with overall accuracy performance (average percent correct over all site variables within each discipline) and descriptively evaluated.

TABLE 17: MEAN TIME (MINUTES) RECOROEO FOR THE INTERPRETATION OF TWO SAMPLE SITES PER STEREO PAIR BY FILM/SCALE COMBINATION

FILM TYPE	NATURAL COLOR			COLOR INFRAREO			B&W IR	RANGE	MEAN
SCALE	1:30,000	1:50,000	1:70,000	1:30,000	1:50,000	1:70,000	1:15,000		
FORESTRY	1.91	1.95	1.66	1.63	1.65	1.76	2.06	.43	1.80
RECREATION	3.28	3.39	3.02	3.22	3.12	3.49	3.15	.47	3.24
WILOLIFE	3.58	3.28	3.64	3.61	2.94	3.11	3.57	.63	3.39

SOURCE: FORESTRY: 102 OBSERVATIONS
RECREATION: 72 OBSERVATIONS
WILOLIFE HABITAT: 42 OBSERVATIONS

3.4.1 Interpretation Time

3.4.1.1 Forestry

No differences in interpretation time were observed between natural color or color infrared films averaged over all scales and interpreter experience/ability groups. Neither scale, considering film types and interpreter groups, nor inventory experience (experiment 1), affected time required for the interpretation of two forest stands. Photo-interpretation experience (experiment 2) and color discrimination ability (experiment 3) did significantly influence time required for interpretation. Less time was taken by interpreters with greater than 24 months photo experience than those with 6-24 months. More time was required by participants with color discrimination errors of 40-70 (mid-range) than those with higher (greater than 70) error scores. A summary of interpreter times averaged over all films and scales is presented in Table 18 with significant differences indicated.

Table 18: Scheffe Multiple Comparison of Significant Interpretation Time Contrasts

A: Photo-interpretation Experience

Group	Time
2	2.08
1	1.79
3	1.59

B: Color Discrimination Ability

Group	Time
2	1.61
1	1.66
3	2.05

The interaction of film and scale was not significant. Experiment 4 revealed no significant differences in interpretation time related to the seven film/scale combinations disregarding interpreter experience/ability.

3.4.1.2 Recreation

No significant differences in interpretation time were observed due to scale or film type, or the film/scale interaction, regardless of interpreter inventory experience (experiment 1), photo-interpretation experience (experiment 2) or color discrimination ability (experiment 3). However, level of inventory field experience, photo-interpretation experience and color discrimination ability did significantly affect interpretation time. Differences in interpretation time for the interpreter ability groups

averaged over all films and scales are summarized in Table 19.

Table 19: Multiple Comparison Tests of Interpretation Time Required by Interpreter Group

Source: Scheffe- Inventory Experience
- Color Discrimination
Tukey - Photo Experience

A: Inventory Experience

Group	Time
1	2.48
3	3.19
2	4.14

B: Photo Experience

Group	Time
1	2.55
2	3.17
3	4.04

C: Color Discrimination

Group	Time
2	2.75
3	2.91
1	4.14

No differences in interpretation time were observed between the seven film/scale combinations analyzed in experiment 4.

3.4.1.3 Wildlife

No differences in interpretation time were detected between film types or scales. Experience with

photo-interpretation (experiment 2) had a negative effect on time with significant differences observed between Group 1 (2.67 minutes), Group 2 (3.47 minutes) and Group 3 (5.93 minutes). Color discrimination ability had a positive influence on interpretation time. Significantly less time was required by interpreters with error scores below 39 (3.01 minutes) than with those above (3.83 minutes). No differences in interpretation time were found between the seven film/scale combinations examined in experiment 4.

3.4.2 Acquisition Costs

Estimates of imagery acquisition costs are presented in Table 20 for the various film/scale combinations tested. Decreased scale results in increased linespacing. Subsequently there is a reduction in number of lines and linemiles, translating into less aircraft flying time. Fewer exposures are required at smaller scales with lower film, processing and reproduction costs. As a tabular representation of cost effectiveness, mean accuracy (average percent correct across all variables by discipline) of each film/scale combination was compiled with acquisition costs (estimated charge per square kilometer). Results are summarized in Table 21.

TABLE 20: AERIAL PHOTOGRAPHY COST ESTIMATES

FILM TYPE	SCALE	LINESPACE (MILES)	LINES	LINEMILES	EXPOSURES	LINEMILE CHARGE	FILM COST	PROCESSING COST	REPRODUCTION COST	MILEAGE CHARGE	TOTAL COST	SQUARE KILIOMETER COST
B&W IR	1:15,000	1.38	13	338	547	18.50	933.	285.	1094.	6697.	9012.	5.79
COLOR NEGATIVE	1:30,000	2.59	7	182	154	18.50	534.	148.	1232.	3589.	5503.	3.54
	1:50,000	4.32	4	104	56	18.50	240.	67.	448.	2035.	2790.	1.79
	1:70,000	6.04	3	78	31	18.50	165.	46.	248.	1517.	1976.	1.27
COLOR INFRARED	1:30,000	2.59	7	182	154	18.50	596.	148.	1694.	3589.	6027.	3.88
	1:50,000	4.32	4	104	56	18.50	268.	67.	616.	2035.	2986.	1.92
	1:70,000	6.04	3	78	31	18.50	184.	46.	341.	1517.	2088.	1.34

SOURCE: CCRS COST RECOVERY PROGRAM: ENERGY, MINES AND RESOURCES INFORMATION BULLETIN, 3RD EDITION, 1977.
AREA: 30 BY 20 STATUTE MILES (17 BY 26 NAUTICAL MILES; 32.2 BY 48.3 KILOMETERS)
FOCAL LENGTH=15.2 CENTIMETERS; FORMAT: 23 CENTIMETERS
FORWARD OVERLAP: 60%
SIDE OVERLAP: 30%

TABLE 21: OVERALL FILM/SCALE ACCURACY AND IMAGERY ACQUISITION COSTS

FILM TYPE	NATURAL COLOR			COLOR INFRARED			B&W IR
SCALE	1:30,000	1:50,000	1:70,000	1:30,000	1:50,000	1:70,000	1:15,000
FORESTRY	44.9	57.4	58.8	64.9	59.2	60.2	53.0
RECREATION	50.9	59.0	53.0	53.0	50.7	52.3	50.5
WILDLIFE	50.8	49.6	46.4	52.4	52.4	54.8	52.7
COST ($/SQ.KM)	3.54	1.79	1.27	3.88	1.92	1.34	5.79

SOURCE: FORESTRY: ACCURACY CALCULATED WITH PRIMARY SPECIES RECOGNITION
RECREATION: ACCURACY CALCULATED EXCLUDING ESTIMATES OF ATTRACTIVENESS AND CAPABILITY FOR CAMPING
WILDLIFE HABITAT: ACCURACY CALCULATED WITH ALL VARIABLES
COST: SEE TABLE 10 FOR BREAKDOWN

3.5 Questionnaire Results

Immediately after completion of the interpretation session, the participant completed a questionnaire indicating individual experience with inventory, interpretation, types of films and scales, and with the operation of the Interpretscope. The interpreter also indicated his/her preference of film/scale combination for the identification of the site variables. Table 22 presents a summary of this opinion survey.

TABLE 22: SUMMARY OF INTERPRETER QUESTIONNAIRES

A: INTERPRETER EXPERIENCE WITH:

	FORESTRY EXTENSIVE	FORESTRY MODERATE	FORESTRY LITTLE	RECREATION EXTENSIVE	RECREATION MODERATE	RECREATION LITTLE	WILDLIFE EXTENSIVE	WILDLIFE MODERATE	WILDLIFE LITTLE
1. BLACK AND WHITE INFRARED 1:15,000	5	10	2	2	8	2	1	2	4
2. NATURAL COLOR	1	4	12	0	6	6	0	0	7
3. COLOR INFRARED	0	1	16	0	6	6	0	1	6
4. SMALL SCALE PHOTOGRAPHY	2	5	10	4	6	2	1	2	4
5. INTERPRETSCOPE	0	1	16	0	3	9	0	0	7

B: INTERPRETER FILM/SCALE PREFERENCE

	NATURAL COLOR 1:30,000	NATURAL COLOR 1:50,000	NATURAL COLOR 1:70,000	COLOR INFRARED 1:30,000	COLOR INFRARED 1:50,000	COLOR INFRARED 1:70,000	BLACK AND WHITE INFRARED 1:15,000	NO PREFERENCE
FORESTRY								
DENSITY	2	0	2	8	1	1	3	0
HEIGHT	2	0	1	1	0	0	13	0
SPECIES	0	0	0	12	2	0	3	0
COMMERCIALISM	0	0	0	3	1	0	11	2
SITE	3	0	0	6	1	2	4	1
RECREATION								
TOPOGRAPHY	0	0	0	6	3	1	2	0
CROWN COVER	0	0	0	8	1	0	3	0
WATER TYPE	0	1	0	8	0	0	3	0
WATER DEPTH	1	0	0	9	0	0	2	0
STABILITY	0	1	0	5	1	0	4	1
DRAINAGE	0	1	0	9	1	0	1	0
ATTRACTIVENESS	2	1	2	5	0	1	1	0
CAP. CAMPING	2	0	1	4	1	0	4	0
WILDLIFE HABITAT								
HABITAT TYPE	0	1	0	1	5	0	0	0
SPECIES	1	0	0	4	2	0	0	0
HEIGHT	0	1	0	2	1	0	3	0
SLOPE	1	0	1	0	3	1	1	0
ASPECT	1	0	0	0	3	2	1	0
SITE	0	1	0	2	3	0	1	0

4. Discussion

Interpretation accuracy and imagery cost effectiveness were evaluated through a series of independent tests. The effects of film type, scale, interpreter inventory experience, photo-interpretation experience and color discrimination ability were analyzed for the identification of each sample site characteristic or quality. The purpose of this section is to assess overall imagery performance by considering all aspects of the individual analyses. The significant differences in accuracy and time between areas (Table 6) indicate that a portion of the systematic variance within the mean square error was extracted and justifies the use of the randomized block layout for analysis. No further discussion of the differences in results between the blocks is attempted other than to mention that the results are applicable to the forest regions for which the photography was acquired.

4.1 Identification Accuracy

Film type, scale or interpreter group did not consistently affect the accuracy for any of the resource characteristics considered. In some cases the interaction of film and scale was significant although no differences were observed between the individual main effects. This indicated that interpretation accuracy was influenced by the level of scale within each film type but was not different when

averaged over the effects of the levels of the other factor. Interactions other than film and scale i.e. film and interpreter group, scale and interpreter group were insignificant. Imagery performance is discussed by discipline.

4.1.1 Forestry

The type of color film only affected the interpretation accuracy of one forest stand characteristic, commercialism. Regardless of scale or interpreter experience/color discrimination ability, results from neither natural color nor color infrared were better for the identification of density, height or species composition. Commercialism, which is a composite term directly influenced by density, height and species, was described more accurately on the color infrared than on the natural color photography. This was consistent with the general trend in interpretation accuracy of the two film types over all stand characteristics. There was a distinct separation in interpretation accuracy of commercialism evident between the film/scale combinations evaluated (Table 8). This significant interaction between the two factors demonstrated that neither film nor scale can be considered independently for photo-identification. Better site identification accuracy was attained on the larger scale color infrared (1:30,000) while the smaller scale (1:70,000) for natural color. The poor performance of the natural color 1:30,000 and natural color 1:50,000 was

directly related to the poor interpretation accuracy attained for height and species respectively.

Site interpretation accuracy with natural color and color infrared were comparable. As with commercialism, site is a composite observation, and is dependent on species, height and terrain. The medium scale black and white infrared tended to be less suitable for these features due to limited spectral information, and the decreased areal coverage. The advantage of the synoptic view provided by the smaller scale color imagery was apparent for the interpretation of site and commercialism, both of which require a broad overview of the terrain. Illustrating this is the accuracy using natural color 1:50,000 (70.6% correct) compared to 1:30,000 (38.2%) and the trend (though not significant) in the accuracy rankings of the color infrared imagery (Table 8).

The scale of color imagery influenced the identification of density, species and site. Interpreters performed as well, or better, on the 1:50,000 and 1:70,000 than on the 1:30,000. It is commonly assumed that crown closure is overestimated at smaller scales due to the appearance of compression. This was not evident here, possibly due to the acceptance of the initial Phase III interpretation as ground control, and the limited densities (mainly C and D) encountered in the sampled stands.

Species composition was more accurately identified on 1:50,000 than on 1:70,000 suggesting that there is a scale

limit beyond which color information does not compensate for poor spatial resolution. Adjustments in optical magnification, or different methods of viewing, might alter this. On an individual film/scale basis, color infrared 1:50,000 was better than both color infrared 1:70,000 and color infrared 1:30,000 for the identification of species class[6]. Shadow effects at the larger scale may have caused confusion while the unfamiliar image rendition and the decreased spatial resolution of the smaller scale resulted in poorer performance. Interpretation accuracy of species with natural color 1:30,000 and 1:70,000 was equivalent to the color infrared 1:50,000. The superiority of color infrared over natural color for vegetation identification suggested by others (Jaques 1976) was not apparent here. Complexity of the forest community, the number of tree species, pure stands, and the occurence of minor species within stands, affects accuracy of interpretation (Losee 1942, Haack 1962, Aldrich 1971, Jano 1980, Kenneweg 1971). Since boreal,transition and subalpine forests in Alberta have a simple stand structure, composed primarily of conifers with limited deciduous occurrence (Hosie 1969), there was a high probability that the interpreters would make the correct choice of species composition. Based on the results of this study, isolating one specific film/scale

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[6]Less difference was observed in the description of primary species and species group (Table 12), although ranking by interpretation accuracy for each film and scale remained similiar.

combination as superior for the identification of species is difficult, and, the decreased ability to discriminate species mixtures with decreasing scale shown in other studies (Marshall and Meyer 1978; Jensen and Colwell 1949) is not evident here.

Photo-interpreters in the Phase III inventory section are trained to estimate heights by measuring differential parallax and recognition of height classes is based on their ability to perceive parallax. This is a common photo-mensuration procedure for calculating tree heights (Anon 1979). Results of this study do not support the contention that measurement of parallax is required to accurately estimate stand height, especially with class intervals of six meters. Relief displacement, and vertical exaggeration, decrease with decreasing scale. Parallax becomes difficult to measure. Nevertheless, interpreters were able to identify height classes just as well on the small scale color imagery as on the large scale black and white infrared. Evidently the interpreters used other visual clues to estimate heights. Texture and shadows contributed directly. Indirectly, species, density and stand age provided additional information. Accuracy may have been considerably different with narrower class limits or the measurement of absolute stand heights. Differences, for significant interactions in experments 1-3, in accuracy by film/scale combination are shown in Table 8. Notable is the position of color infrared 1:30,000, which was generally

better than color infrared 1:50,000 or natural color 1:30,000. Conversely, natural color 1:50,000 performed better than 1:30,000. This interaction is partially explained by the film types themselves, assuming that parallax is not the determining factor in estimating height class. Different visual data is available on the two films. Haze effects are minimized on the color infrared resulting in greater color contrasts and sharper detail. At 1:30,000 the low sun angle produced long tree shadows which were enhanced on the color infrared. Consequently, interpreters could rely on more direct information for height estimation on the color infrared 1:30,000 than on natural color 1:30,000. Without this familiar perspective to ground scale, interpreters were left with only indirect means for height estimation.

Level of interpreter experience, whether field inventory or photo-interpretation, affected only the accuracy of species identification. Participants with more than two years experience in the field performed significantly better than those with less than six months experience. Although no contrast of interest was significant (Table 10), those with more photo-interpretation experience tended to be more accurate than inexperienced participants. This suggests the need for an intensive training program for potential interpreters, both in general photo-interpretation procedures and practical field work. The effects of color discrimination were inconclusive. Accuracy of species

recognition was higher for interpreters with moderate color discrimination errors (Group 2). However, effects of color discrimination ability were inconsistent as participants with the lowest scores (Group 1) did not perform better than those with poorer color perception. Arbitrary selection of the color discrimination group classes might have caused this disparity. Interpretation of site index was the only other forest stand characteristic influenced by interpreter color perception although no contrast of interest was significant. Identification of density and height were not found dependent on color perception. Identification of species composition, commercialism and site were affected by interpreter color discrimination ability to some extent, although interpreters may have compensated for defective color perception with increased object visualization.

Personal preferences, indicated in the questionnaires, suggested that subjective opinions on imagery suitability should be treated with caution. There was a direct correlation between amount of experience with a film/scale combination and preference for it (Table 22). The brief introduction to the principles and interpretation of small scale natural color and color infrared imagery and the "one-shot" interpretation session did not allow most to become comfortable with the photography. Interpreters generally preferred larger scales, convinced that the increased detail allowed easier and more accurate identification. Despite this, interpretation of the larger

scales was not significantly better as previously noted by Northrop and Johnson (1970). Color infrared 1:30,000 was preferred by the forest inventory interpreters over conventional black and white infrared photography for density, species and site. However, interpretation accuracy attained with this film/scale combination did not warrant this attention. Conversely, opinion was biased against natural color due to its washed out appearance, yet accuracy was comparable for the interpretation of most stand characteristics.

4.1.2 Recreation

In general, accuracy of identification for the recreation variables was less affected by the experimental factors. There was high variability in the observations within the groups caused by the inexperience of the interpreters with the film/scale combinations and the interpretation specifications. Olson, Tombaugh and Davis (1969) suggest that errors in describing potential recreation sites may be less dependent on imagery type and photo-interpretation experience than on unrealistic classifications used for site descriptions and interpreter experience in the area viewed. In this study, failure to separate inventory and management considerations, especially for the estimates of attractiveness and capability for camping, resulted in considerably lower interpretation accuracy across all film/scale combinations (Table 7). There

was some confusion as to what terrain characteristics should be used for these observations. Personal preference in aesthetics of the field technician as well as the participants appeared to play an important role.

Significantly better identification was attained for crown type and water depth on the natural color than on color infrared. The natural appearance of the tree species provided better clues for recognition of the five classes than the "false" appearance on the color infrared. Natural color was also superior for estimates of water depth, though not for water type. Mercanti (1977) reports that color infrared gives more contrast between dry and wet soils and may be superior for internal drainage interpretation, but this was not observed in this study. Interpreters found it difficult to locate the narrow band along the water courses to which the estimate of backshore drainage applied, especially on the small scale photography. Further confusion was due to the gradual change in elevation and vegetation away from the water, tending to mask soil conditions as observed by others (Anderson 1973). No allowance was made for season of photography nor weather conditions prior to imagery acquisition. Performance of the photography for drainage interpretation is therefore applicable only to "average" ground conditions experienced during late summer and early fall.

Regardless of film type, interpreter inventory/photo-interpretation experience or color

discrimination ability, imagery scale influenced the identification accuracy of only two recreation site characteristics, topography and water type. Identification of topography tended to be better on the larger scales (1:30,000 and 1:50,000) regardless of film type. Greater relief displacement, and more vertical exaggeration, aided interpreters in duplicating field estimates of relief. Less difficulty was observed in the identification of water type, with 78 percent accuracy recorded across all film/scale combinations (Table 7). Interpretation accuracy was significantly better on the 1:50,000 than on the 1:30,000 scale illustrating the advantage of greater synoptic view on smaller scale imagery for tracing water course boundaries.

Neither inventory experience, photo-interpretation experience or color discrimination ability affected interpretation accuracy of any recreation site characteristic described on any film/scale combination. Evidently, the basic training received by all participants provided sufficient information for the interpretation of the simple site classes used. As well, it appeared that color perception of the interpreter was not a limiting factor for the identification of the recreation variables examined.

Recreation interpreters preferred color infrared 1:30,000 for the interpretation of most variables (Table 22). Again, performance did not justify this choice, illustrated by the higher accuracy for crown type

identification on the natural color photography as opposed to the color infrared. Though opinion was against it, the choice of the smallest scale seems reasonable, particularly as recreation inventories are usually low intensity and designed only to evaluate potential sites.

4.1.3 Wildlife Habitat

Participants in this discipline generally had less exposure to inventory procedures and photo-interpretation (Table 22). Lower interpretation accuracy across most variables reflected this. Little advantage was apparent with any specific film/scale. Conventional black and white infrared did not perform significantly better than the color film/scale combinations for the identification of any habitat characteristic. Slope was discounted as accuracy was very high with all photography. Interpreters had no difficulty separating slopes of less than 30 degrees from more steeper terrain. There was some confusion with the identification of vegetation species and deciding which component occupied the dominant position. The larger scale was more suitable for estimating heights of shrub and mixed vegetation, since it was not visible on the smaller scale imagery. Interpreters were more successful with color infrared than with natural color for the interpretation of site condition despite difficulties in describing site condition under the classes specified. Required ground detail was obscured on the natural color. Importance of the

fine detail was illustrated with higher accuracy on the 1:30,000 than on the smaller scale imagery.

Field experience was not considered as a factor in interpretation accuracy due to an insufficient sample within the groups. Photo-interpretation experience had a positive effect on the identification of site condition. Evidently, interpretation of the other site features required only basic habitat knowledge common to all participants and did not depend on photo skills. This was previously observed by Seher and Tueller (1973). Also, color discrimination had no effect on interpretation. However, all interpreters exhibited high average ability with error scores ranging from 24 to 73. Separation into the two groups (Table 1) was unnecessary.

Recent literature (Parker 1978, Fine, Dye and Bosworth 1978, Baumann, Johnston and Gosselink 1978, Watson 1977, Pettinger, Farmer and Schamberger 1978) suggest the use of color infrared photography for wildlife habitat inventory. Results of this study do not support this considering the resource features investigated here. Interpreters preferred color infrared 1:50,000 for the interpretation of most habitat characteristics however this film/scale combination was not superior to the others evaluated.

4.2 Costs

Intuitively, it seems reasonable that interpretation would be easier and faster on imagery with high information content. Results of this study partially support this premise. Confounding the effects of film type are scale, interpreter experience and color discrimination ability. Total interpretation time may increase with larger scales of natural color and color infrared (Ulliman and French 1977). Black and white infrared at only one large scale has been compared to natural color and color infrared at three smaller scales, having a corresponding increase in number of sample sites inspected. The time required for the description of two sites per film/scale combination served as an indication of photo-interpretation variable cost, which could be reasonably extrapolated to the interpretation of the effective area of a photo. Time required for delineation, stereo set-up and orientation was ignored. The discussion assumes that less time for interpretation is desirable.

No differences were observed in times required for the interpretation of any color film/scale combination in any of the disciplines. Contrary to Marshall and Meyer's report (1973) that interpretation time increases with smaller scales, the decrease in spatial resolution at smaller scales did not result in participants taking more time for interpretation of the photography. Evidently, the time required for the assembly of available visual clues for

identification was not dependent on scale. Similarily, interpreters took no longer on natural color than color infrared, although the green cast due to haze, tended to obscure ground detail and was quite noticeable on the smaller scale natural color imagery. Apparently the unfamiliar color rendition of the terrain features on the color infrared photography and the reduced spatial resolution on smaller scales resulted in equivalent interpretation times.

Pooled times for the color imagery (mean interpretation time across all three scales) provided a means of comparison of film types with medium scale black and white infrared. No differences in interpretation time were observed with the wildlife interpreters, most of whom had little experience with any of the film/scale combinations presented. However, forestry interpreters took significantly more time for interpretation on the black and white infrared, with which they are familiar on a day to day basis, than the small scale color infrared with which none had extensive experience. Imagery characteristics, as well as experimental conditions may explain this anomaly:

1. Forest stands on the small scale color infrared appeared smaller, requiring less time for the interpreter to scan across and become familiar with local terrain and vegetation conditions. Greater synoptic view allowed quicker orientation. Color information enhanced identification of species association, and subsequently

reduced the time required for a decision on composition.

2. A larger amount of spatial information (texture, branching habit, shadows) and relief displacement was presented on the medium scale photography which required time for assimilation. More detail than required for a simple overstory classification may have caused confusion, contributing to increased time for interpretation.
3. Although experienced with the conventional photography, interpreter sessions were undertaken on the Interpretscope, an instrument with which most had no practice and at an unfamiliar magnification. Despite assurances that individuals were not being tested, the participants felt obliged to perform well, taking longer than necessary to interpret the black and white infrared.

In contrast to forestry, recreation interpreters took longer with color infrared than black and white infrared. Questionnaire results reveal that more participants had moderate to extensive experience with the conventional imagery and arrived at decisions more quickly. Recreation inventory is less production oriented and therefore participants experienced less test tension. More interest was shown in the color infrared and the interpreters took advantage of the presentation to examine unusual terrain or vegetation prior to making a decision.

Significant differences in identification time were observed between interpreter groups. Amount of field inventory experience did not influence forestry interpreters but had a negative effect on recreation interpreters. Participants with more experience evidently became more involved with the appearance of features on the imagery, taking more time (simply out of interest). Amount of general photo-interpretation experience influenced time taken by interpreters in all three disciplines. Forestry interpreters with greater experience tended to take less time. However, results were inconclusive: while interpreters with more than 24 months experience required significantly less time than those with 6 to 24 months experience, there was no difference between interpreters with less than 6 months experience and those with more than 24 months. This may be explained by the weighting received by only one interpreter's results in Group 2 with 12 observations assigned to Group 2 and 4 observations to Group 3. Average interpretation time for Group 2 appears out of place in the ranking possibly due to an unrepresentative sample.

Times recorded for the recreation and wildlife interpreters contradict the trend toward decreased time with greater experience. Photo experience had a negative effect on interpretation time. Participants more familiar with remote sensing showed more interest in the appearance of terrain features on the various film/scale combinations. Apparently, since they are not normally involved in a

production operation, they were not concerned with time and felt no incentive to finish quickly.

A significant effect of color discrimination ability on interpretation time was evident only with the wildlife biologists where significant differences were observed between the two color perception groups. Interpreters with higher error scores required more time to decide on terrain description. This was reasonable since the participant confusing colors in the discrimination test could be expected to have difficulty separating meaningful colors on the natural color and color infrared photography. Inappropriate separation into color discrimination groups and the use of total error score, rather than an evaluation of color confusion zones by individual, may account for the reverse trend shown in the other disciplines. Forestry interpreters with high error scores (70 plus) generally required more time for interpretation although not significantly more than those with the lowest error scores. Participants with moderate scores (40 to 70) took the least time, though not significantly less than those with the lowest scores. This suggests that the class limits for color discrimination were inappropriate or that color discrimination (total error score) is an insignificant factor. All interpreters had at least normal average discrimination (Farnsworth 1957): average error scores ranged from 8.0 to 94.0 (Appendix G). Separation of the interpreters into three classes may have been unnecessary.

The range in interpretation time was only .44 minutes, which may become insignificant in an operational setting. As well, no meaningful contrasts were isolated by this separation of times. Recreation interpreters showed a greater range in error scores (125) with a shift toward higher errors. Participants with low error scores (0 to 39) took significantly longer than those with scores of 40 to 70. Interpreters having less difficulty discriminating colors might be expected to require less time to come to an interpretation decision. More research into this may be required to set proper limits on color discrimination ability required for interpreters working with various film types.

Imagery acquisition costs were calculated for the coverage of a moderate sized tract (1550 square kilometers). Estimates from the Canada Center for Remote Sensing Center were based only on aircraft time over the target and did not account for down time due to unfavorable weather conditions. Equal linemile charges were assumed at all scales. Athough commercial estimates would reflect these factors, these calculations should provide a reasonable means of cost comparison between the film/scale combinations evaluated. Examination of Table 20 reveals that, on a frame by frame basis, film and associated processing and reproduction costs are much higher for natural color and color infrared than black and white infrared. Although the cost of a photograph increases with altitude due to increased equipment costs and

allowance for weather (Ulliman 1975), the cost of block coverage decreases with higher altitudes. Scale is the most important factor in acquisition cost: the main expense is related to the taking of the photos (Howard 1970). Hindley (1957), in a comparison of 1:15,000, 1:60,000 and 1:90,000 black and white panchromatic coverage of a 5700 square kilometer block, found that overall acquisition costs decreased from $7770.00 , $1265.00 to $945.00 respectively. Estimates from this study support these findings. There was a significant cost reduction with decreasing scale, despite higher single exposure costs. At 1:15,000 approximately 16 times more photos were required than at a scale of 1:70,000. Increased spacing between lines, resulted in fewer lines and lower linemile charges. Fewer photos require less handling time in set up and data transfer procedures.

Overall identification accuracy attained with each film/scale combination was tabulated with imagery acquisition cost. Although no differences were observed in interpretation performance there was a definite separation in cost between scales (Table 20). It was observed that interpretation accuracy may be sustained or increased at lower acquisition costs. Higher expenditures for the acquisition of larger scales did not result in better interpretation performance. Beaubien (1975) states that the smallest scale should be used provided the inventory objectives are met. External considerations limit choices, however selection of the smallest scales tested here would

cost less with no significant reduction in the accuracy of interpretation.

5. Conclusions

Medium-small scale natural color and color infrared photography are effective alternatives to conventional large scale black and white infrared for the identification of selected resource features. Current inventory specifications consist of broad category classes for wildlife habitat, recreation sites and forest stand overstory. It is evident that experienced photo-interpreters do not require the amount of detail available on large scale photography to accurately describe these features. The addition of color information at smaller scales compensates for reduced spatial resolution. Interpreter preference is not a reliable indicator of imagery suitability. Preference generally was to large scale black and white infrared or 1:30,000 color infrared. Neither of these demonstrated interpretation results significantly better than the other film/scale combinations. Granting interpreter inexperience with this "new" technology, there remains an apparent ingrained bias towards large scale based on the assumption that spatial resolution, and the ability to measure parallax, results in better photo-interpretation. This is questionable: a limit may be reached at which increased visual information causes confusion rather than clarification as to the identity of resource characteristics.

No advantage in the interpretation of any of the resource features was evident with the use of medium scale black and white infrared photography as opposed to the

smaller scale natural color or color infrared imagery. Regardless of scale or the experience of the interpreters, color infrared appeared to be more suitable than natural color for the interpretation of commercialism (forestry) and wildlife habitat site condition. Natural color was better for the identification of crown type and water depth on the recreation sites. Neither interpretation accuracy for the other resource characteristics, nor interpretation time were affected by the choice of film.

Selection of scale, regardless of film or interpreter experience, affected the interpretation of stand density, species composition, site index, topography, water type and habitat site condition. With the exception of topography and site condition, no advantage was demonstrated in choosing a larger scale than 1:50,000 for the identification of the other resource characteristics. The time required for photo-interpretation by any set of interpreters was not influenced by the choice of scale.

Interpreter field inventory experience affected only the identification of species composition in forest stands and the time required by recreation interpreters, where in each case increased experience resulted in better performance on the small scale color imagery. The level of experience did not affect interpretation accuracy of the other resource characteristics nor time required by forestry or wildlife interpreters.

Increased photo-interpretation experience resulted in better species composition identification in forest stands, and a more accurate estimate of wildlife habitat site condition. The interpretation accuracy of other resource characteristics was not influenced by this factor. Photo experience had a positive effect on interpretation time required by the forestry photo-interpreters but did not result in reduced times for the recreation or wildlife interpreters.

Interpreter color discrimination ability had a positive influence on the identification of tree species composition in forest stands. Color perception had an inconsistent effect on the identification of site index and the times required by all interpreters, and did not influence the accuracy of interpretation of other resource characteristics.

The analysis of acquisition costs for the small scale color imagery indicated that on a frame by frame basis, the cost of black and white infrared is appreciably less than either of the color films. This remains constant. However, with smaller scale color imagery, areal coverage is more extensive on each photo reducing the number of frames required for stereoscopic coverage and therefore the cost. As a result, total cost of imagery acquisition is reduced, with equivalent interpretation accuracy of resource characteristics.

6. Recommendations

Results of this study suggest that small scale natural color or color infrared photography should be considered for an operational pilot study using on-line procedures. For the selected resource features, comparable identification accuracy to that of the medium-scale black and white infrared imagery has been attained with no increase in identification time required, and a reduction in acquisition costs.

Of the film/scale combinations evaluated for this study, color infrared 1:50,000 is recommended for multiresource inventory. Overstory vegetation types are easily identified by inexperienced photo-interpreters on this imagery and the large synoptic view at this scale is advantageous to feature identification and management planning in forestry (recognition of fire boundaries), recreation (location and access), and wildlife (estimation of habitat dispersal). In particular, interpreters expressed interest in this imagery for experimental work, and it is expected that with more working experience they would prefer it to conventional photography.

Further research is suggested to address the following questions:

1. Is medium-small scale black and white infrared a suitable alternative for the identification of resource characteristics and qualities?
2. What are the ramifications of using small scale

photography on the specifications for minimum size area delineation, vegetation description, and data transfer to base maps?

3. Can positive color prints serve as a cost effective alternative to positive transparencies for interpretation?
4. What are the effects of interpreter knowledge of the terrain in a specific area, variable optical magnification, interpretation experience with the selected imagery types and scales, and interpreter age on interpretation accuracy of resource characteristics and time required for interpretation?
5. Can understory species, and bracketed species be identified accurately on medium-small scale imagery?
6. What are the effects of interpreter color confusion, within specific zones, on the accuracy of feature identification?

Regardless of the imagery selected, additional questions related to management implications arise as a result of this study, in particular:

1. What level of identification accuracy and consistency is required by land managers?
2. What are the associated costs in equipment and manpower requirements for the implementation of a medium-small scale color imagery interpretation system.

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8. Appendix A: Example Sample Sites

Illustrated on plates 1 through 5 are selected forest points, stands, recreation sites and wildlife habitat sites delineated on natural color and color infrared photos over the three study areas. Sites are described below:

Plate 1: Area 1: Natural Color 1:67,500
Point 5: D1PA
Stand 16: C3SwP(A)-R-G
Stand 17: C1Sb-U-F

Plate 2: Area 1: Color Infrared 1:29,400
Point 10: B3PA(Sw)
Stand 15: C4PSwA-L-G
Stand 18: C3PSw(A)-L-M
Recreation Site 10: 12531345

Plate 3: Area 2: Color Infrared 1:54,000
Point 3 : B3Sw(Sb)
Point 8 : B3Sw
Stand 1 : B2SwSb-R-F
Stand 8 : C2P(Sw)-R-F
Stand 9 : B3P(Sw)-R-M
Stand 15: C2A(Sw)-H-F

Plate 4: Area 3: Natural Color 1:26,800
Point 5 : C2P
Stand 12: C3PSw-L-M
Stand 13: C2P-R-F
Stand 14: D2P-R-M
Recreation Site 2: 24542172

Plate 5: Area 3: Color Infrared 1:64,900
Point 5 : C2P
Stand 11: D3P-R-G
Stand 12: C3PSw-L-M
Stand 14: D2P-R-M
Recreation Site 2 : 42542172
Recreation Site 4 : 14551166
Recreation Site 11: 15312254

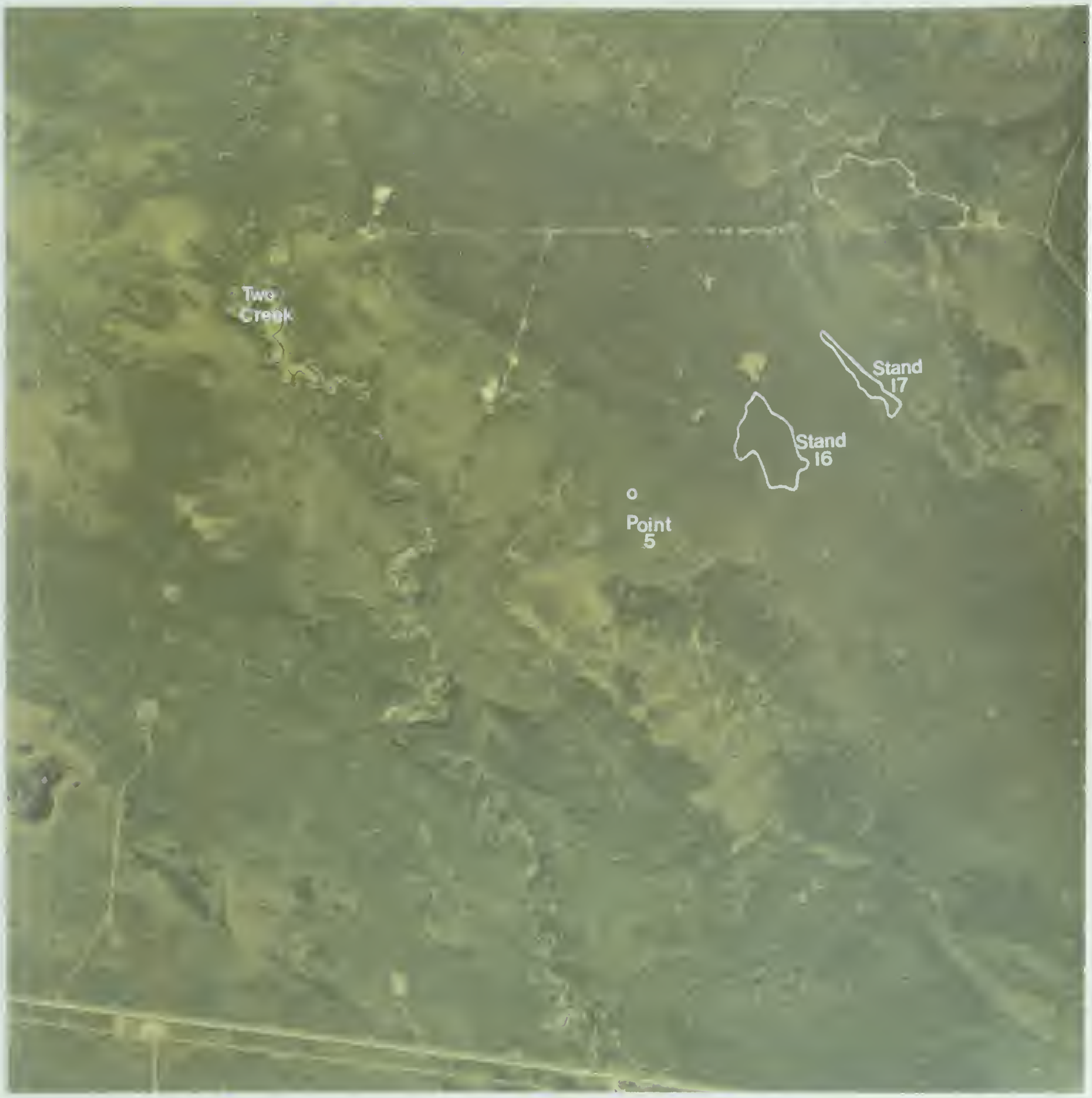

Plate 1: Sample Site Locations on 1:67,500 Natural Color Photography
Area 1: Two Creek, Alberta

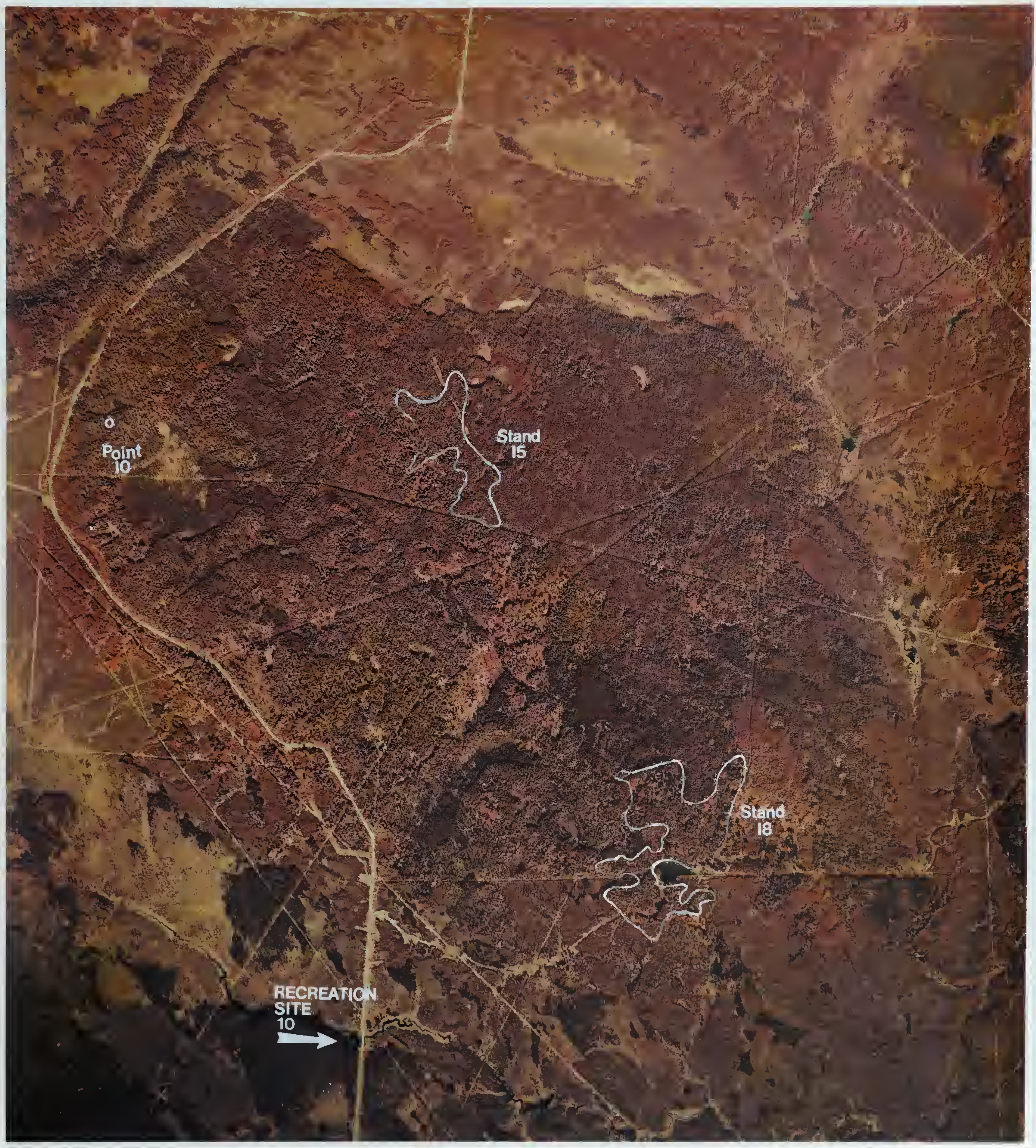

Plate 2: Sample Site Locations on 1:29,400 Color Infrared Photography
Area 1: Two Creek, Alberta

Plate 3: Sample Site Locations on 1:54,000 Color Infrared Photography
Area 2: Cache Percotte Forest

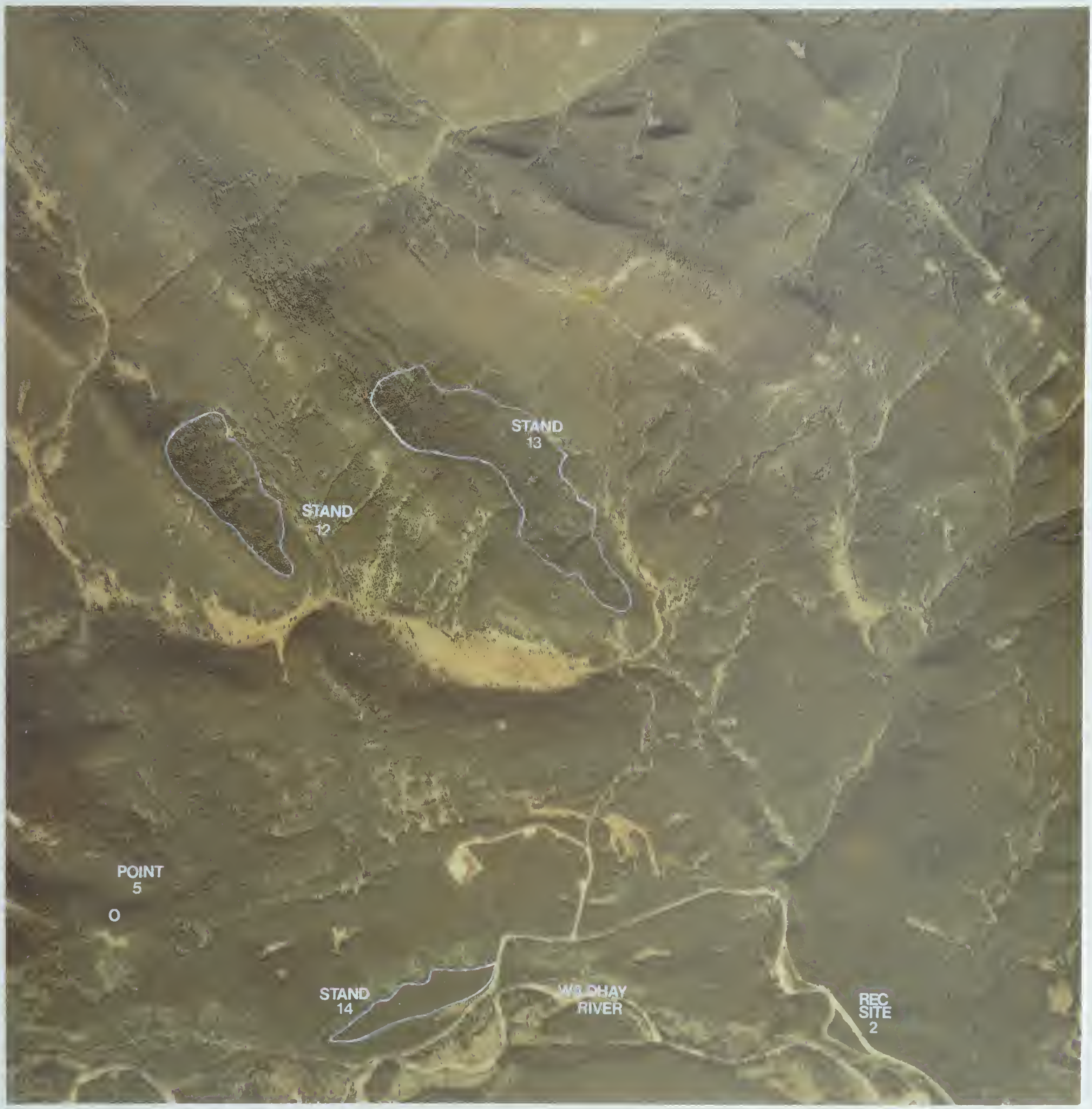

Plate 4: Sample Site Locations on 1:26,800 Natural Color Photography
Area 3: Wildhay River

Plate 5: Sample Site Locations on 1:64,900 Color Infrared Photography
Area 3: Wildhay River

9. Appendix B: Forestry Interpretation

TABLE 1: PHOTD INTERPRETER DBSERVATIDNS FDR INDIVIDUAL TIMBER TYPES

TWD CREEK STANDS

	CDLDR 1:30000		CDLDR 1:50000		CDLDR 1:70000	
	F12	F13	F1	F2	F15	F20
GRDUND	B2P(A) RM	C3SBP(S) RG	C3SWA LM	C3PA LM	C4PSWA LG	C3PSW(A) LM
1	B4P(A) LG	C3SWS LM	C3SWP LM	C3SWP(A) LG	C4P LG	C3P(A) RM
2	C3PA RM	C3SWA LM	C3SWP(A) LM	C3AP(SW) RM	C3A(SW) HM	D2PA RF
I 3	B3PA LM	C2SWA UF	C3SWA LM	C3PA LM	C3SWP(A) LM	D3P(A) LG
N 4	B3SW(A) RM	B3SW LF	C3SW LM	C2SW(A) RF	C3P LM	C3P(A) LM
T 5	C3P(A) LM	C2SWS RF	C3AP HM	C3AP HM	C3P LG	D3P(A) LM
E 6	C3AP LM	C3SWA LM	C3SWP LM	C4AP HG	C4AP LG	C3PA LG
R 7	C3PASW LM	C2SWS(A) RF	C2SWP RM	D3PA LM	C4SWP LG	D3PA RM
P 8	C3PSWA LM	C2PSW(A) RF	C3PSW LM	D3PSW LM	D3P(SW) LG	D3PA LG
R 9	C3P(A) RM	C2SBS RM	C2SBS RM	D2PA RM	D3A(SW) HM	D3A HM
E 10	C3PA LM	C2SB(P) UM	C3SW LG	C3P(SW) LG	C3PA LM	C2P(A) UM
T 11	B3P(A) LM	C2SB(S) RM	C3P(SW) LM	C3ASW LG	D3P(A) LG	D2P(A) UG
E 12	C3PA LM	C3SW LM	C3SW LM	C3A HM	C3SW LM	C3P(A) LM
R 13	C3P(A) LM	B2SBS RM	C2SW(P) RF	C3AP HM	C4SW LM	C3P(A) LM
14	C3P(A) LM	B3SW(A) LM	C3SWA LM	B2SWA RF	C3P LM	B3ASW HM
15	B4PA LG	C3SWP(A) LM	C2SW(P) RF	C3PA RM	C3PA LM	C4PA LG
16	C3SW(A) LM	B4SWA LG	C3SW(A) LG	D3A HG	C3PA HM	D2P(A) RM
17	B3PA(SW) LM	C3SW(P) LM	C2SW(A) LF	B2PSW RF	C2P LM	C2P(A) LM

TABLE 2: PHOTD-INTERPRETER OBSERVATIONS FDR INDIVIDUAL TIMBER TYPES

TWD CREEK STANDS

	C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B/W 1:15000	
	F10	F11	F3	F4	F8	F9	F16	F17
GROUND	C3SWPA LM	C3SWPA LM	C3A(P) HM	C4SW LM	C3SWPA LM	D3P(A) LM	C3SWP(A) RG	C1SB UF
1	C4SWA LM	C4SWA LM	C3ASW HM	C2SW RF	C3PSW(A) LM	C3P(A) RM	C3PSWA LG	C2SB(P) RM
2	C3SWA LG	C3SWA LG	B3AP(SW) RM	C3SW(P) LM	C3SWPA LG	C3PSW(A) LG	C3AP(SW) RF	C1SB UF
I 3	D4SWP(A) LM	C3SWA LM	B3ASW(P) HM	C2SW(A) UM	C4PA LG	C3P(A) LM	B3A(P) HM	B2SWS RF
N 4	B3SW LM	C3SW(A) LM	B2ASW HM	C3SW LM	C3PSW(A) LM	C3P(SW) LM	C3PSW(A) LM	B2P RF
T 5	C3SWA RM	C3SWA RM	C3PA(SW) RM	C2SW RF	C3PA(SW) LM	D3P LM	C2PSW(A) RM	C2SW UF
E 6	C3SWA LM	C3SWP(A) LM	B3A(P) HG	C3SWP LM	C3PA(SW) LM	C3PA LM	C3PA LM	B2SB RG
R 7	C3SWA LM	D3SWA LM	C3AP HM	D2SWS RM	D3SWA RM	C3SWA LM	D4PSWA RM	C2SWS UF
P 8	D3SWP LG	D3SWP LG	C3PSW LF	D3SWP LM	D3PSW LG	D3PSW(A) LG	D3PA LG	C3SWP LF
R 9	D4SW(A) LG	D3SW(A) LM	C3SWA LM	C3SW LF	D3PSW(A) RM	D3PSW RM	D3SWA RM	C1SB UM
E 10	C3SW(A) LM	D3SW(A) LG	C2ASW UM	C2SW UF	D3PSW(A) LG	D2P(SW) RM	C3PA LM	C2SB RM
T 11	C3SW(P) LM	C3SWP(A) LM	C4ASW LM	C3SW(A) LG	D2PSW RG	D3P(SW) RG	C3PA LG	C2SB(P) RF
E 12	C3SWA LM	C3SWA LM	C3ASW HM	C3SW LM	C3SW(A) LM	C3P LM	C3SWA LM	C2SB RM
R 13	C3SWP(A) LM	C3SW(A) LM	C3ASW LM	C3SW LM	C3P(A) LM	C3P RM	C4SW(A) LG	C2SB(S) UM
14	C3SW(A) LM	C3SW(A) LM	B3SW(P) LM	C3SW LM	C3P LM	C3P LM	C3SWP(A) LM	B2SWS RF
15	C4SW(P) LG	C4SWP(A) LG	B3APSW LM	C4SW LG	C4SWP LM	C4SWP LG	C3PSWA LM	B2PSB RM
16	C3SWA LG	C3SW(A) LG	C3ASW LG	D3SW(A) LG	C3P(A) LG	D2P(A) RM	C3SWA LG	C1SB UF
17	C3SWA LM	C3SWPA LM	B2AP HM	C2SW(A) LF	D3P(A) LM	C3PA LM	C2PA LM	B1SB UF

TABLE 3: PHOTD INTERPRETER DBSERVATIDNS DF TIMBER TYPES

CACHE PERCDTTE STANDS

		CDLDUR 1:30000				CDLDUR 1:50000				CDLDUR 1:70000			
		F7		F8		F13		F14		F16		F17	
	GRDUND	B2SBA	UG	C2P(SW)	RF	B2A(SW)	UM	B2A(SW)	UM	D3P	RG	D3P	RG
	1	C2SBS	RM	C4P(SW)	LG	C2ASW	HM	B3A(P)	HM	C3P	LG	C3P	LG
	2	B2AP(SW)	HF	C3P	LG	C2SWPA	RM	C3PA(SW)	RM	D3P	LG	C3P(SW)	LG
I	3	B2SW(S)	UF	C3PSW	LM	C3PA	HG	B3SWA	LM	D3P	LG	D3PA	HM
N	4	B2A	HM	C3SW(P)	LM	C2P(A)	RM	B3A	HM	D2SW	UF	C2SW	RM
T	5	C1SWA	UF	C3P	LM	C3SWA	RG	C2ASW	UM	D3P(SW)	LM	C3P	LG
E	6	B3ASW	HG	C3PSW	LM	C3A(P)	HG	B3APSW	HM	D3P	LG	C3AP	LG
R	7	C2SWA(S)	UF	D3PSW	RM	C2SWA(P)	RM	C2SWA	RM	D3AP	HM	D3PSW	LM
P	B	C2PSW(A)	RF	D3PSW(A)	LG	C3PSW(A)	LM	B2PSW	RF	D3P(SW)	LG	D3PSW	LG
R	9	C2SBA(P)	HM	D3P(SW)	RM	C2ASW	HM	C2ASW	HM	D2P	RM	D2P	RM
E	10	C2SWP	UM	C3P(SB)	LM	C2PSB	UM	C1SBP	UM	D3P	LG	D2A	UM
T	11	B2A(SB)	HF	C3P(A)	LG	C2SW(A)	HM	B3A(SW)	HM	D3A(SW)	HG	D2A	UG
E	12	B3ASW	HM	C4P	LG	C3ASW	HG	C3ASW	HM	D3P	LG	D3P	LG
R	13	B2SWA	RM	C3P(SW)	LM	C2SWA	UM	B3PA	LM	D3P	RM	D2P(SW)	RF
	14	B3A(SW)	HG	C2P	RF	B3A	HG	B3A	HM	C3P	RM	C3P	LM
	15	C2ASB	HM	C3PSW	LM	C2PA(SW)	RM	B3ASW	HM	D3P	LM	D3P	LG
	16	B3SBP	UG	C3PSB	LG	C2ASW	HG	B3ASW	LM	D2P	RM	D2P	RM
	17	B2ASW	UF	C3P	LM	C2PSBS	RM	C2SWS(P)	RM	D3P	LM	D3SW	LM

TABLE 4: INTERPRETER OBSERVATIDNS OF TIMBER TYPES

CACHE PERCDTTE STANDS

		C.I.R. 1:30000				C.I.R. 1:50000				C.I.R. 1:70000				B/W 1:15000			
		F1		F9		F6		F10		F3		F18		F5		F15	
	GROUND	B2SWS	RF	B3P(SW)	RM	C2A(SW)	HF	C3SW	LM	C2SW(A)	RM	C2SW(P)	RM	C3PA(SW)	LM	C2A(SW)	HF
	1	B2SW(P)	RF	C4P	LG	C3A(SW)	HM	C3SW(A)	LM	C3PASW	LM	C3SW(P)	LM	C3P(A)	LG	C3ASW	HM
	2	A2SWP	RF	C3PA	LG	C3PA(SW)	RM	C2SWP	RF	C3PA(SW)	LM	C2SW(A)	RG	C3PSWA	LG	C3A(SW)	HG
I	3	B3SW(P)	RM	C3P(A)	LM	C3AP(SW)	LG	C3SWP(A)	LM	C3P(A)	LM	C3SWA(P)	LM	C3SWA	LM	C3A(SW)	HM
N	4	B3SW(A)	LM	C3P(A)	LM	C2A(SW)	HM	C3P(SW)	LM	C3SWP(A)	LM	C2PSW	RM	C3P(A)	LM	C3A(SW)	HG
T	5	B2SW(A)	UF	C3PSW(A)	LM	C3AP(SW)	HG	B3SWA	RM	C3PSB	UM	C3SW(P)	RM	C3SWA(P)	LM	C3ASW	HG
E	6	B3AP	HG	C3PA	LM	C3A(P)	HM	C3PSWA	LM	C3ASW	LM	C3SW(A)	LG	C3PA(SW)	LM	C3AP(SW)	LM
R	7	B3P(SW)	LM	D3PSW	LM	C2ASW(P)	HM	D2SWA	UF	C3PA	RM	D2SWP	UM	C4SWA(P)	LG	C3A(SW)	HM
P	B	B2SWAP	RF	D3PA	LG	C2PSW	RF	C3SWP	LM	C2PA(SB)	RF	D2PA	RF	D3SWP(A)	LG	D3ASW	LM
R	9	B2SW(A)	RM	C3PA(SW)	LM	C2A(SW)	HM	C2SWP(A)	RM	C2SBA(P)	RM	D2SWA(P)	RM	C3SW(A)	LM	C3A(SW)	HM
E	10	B2SWA	UF	C3P(SW)	LM	C2A(P)	UM	C1SB(A)	UF	C1SBA	UF	C2SWA	UF	C3SW(A)	LG	D3ASW	HM
T	11	A3SW(A)	UM	C3P(A)	LM	C3AP(SW)	LM	C3PSW(S)	LG	C2P(SB)	RM	B2SW(A)	UM	C3SW(A)	LM	C3A(SW)	HM
E	12	B3SW	LM	C3P	LM	C3ASW	HM	C3SW(A)	LM	C3SWA	LM	D3SW	LM	C3SW(A)	LM	C3ASW	HM
R	13	B2SW(A)	RF	C3PA	LM	B3A(SW)	HM	B3SW(A)	LM	B3SW(A)	LM	C2SWA	RM	C3SW(A)	LM	C3A(SW)	HM
	14	B3SW	LM	C3P	LM	C3A(SW)	HM	C3SW(P)	LM	B3PSW(A)	LM	A3SW	RM	C3SW(A)	LM	C3ASW	LM
	15	B3SWP	LM	C4P(SW)	LG	C3PASW	LG	C3SWP	LM	C3SWP	LM	C3SW	LM	C4SWA	LG	C4SW	HG
	16	B2SB(P)	UM	C3P(A)	LG	C3ASW	HG	D2P(A)	RM	C3PSB(A)	RM	C2SBP	UM	C3SW(A)	LG	C3A(SW)	LG
	17	B2P	RF	C3P	LM	C3AP	HG	C3PA	LM	C2SWA	RF	D3SW(P)	LM	C3SWPA	LM	C3PSW	LM

TABLE 5: PHOTO INTERPRETER OBSERVATIONS OF TIMBER TYPES

WILDHAY RIVER STANDS

	COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000	
	F3	F4	F7	F8	F11	F12
GROUND	B2SW(FB) RF	D2P RF	C3SWP LM	C3SWFB LM	D3P RG	C3PSW LM
1	C3SWP LM	C2PSW RF	C2PSW RF	C2PSW RF	C2P RM	C2P LF
2	C3SW LF	C3P LF	C3SW LF	C4SW LG	D2P RM	C4SW(P) LM
I 3	D3SW(P) LF	D3P LM	C3SW(P) UM	C3SWP UM	D2P RM	C3SW(P) RM
N 4	C3SW LF	C3PSW LM	C3P LG	C3PSW LM	D2SW RM	B3SW LM
T 5	C3SW LF	D3P LM	D3SW RM	C3SW RM	D2PSW RM	C3P RM
E 6	C3PSW LM	C3SWP LF	C3SW(P) LM	C3SW LM	C3PSW LG	B3SWP LM
R 7	C3SWP LM	D2SW RF	D3SWP LM	D3SWP RM	D2SW UM	C3SW LM
P 8	D3SWP LM	D2PSW RM	D2P RM	D2P RM	D3P(SW) LG	C2SWP RF
R 9	C2SW RF	D1P UF	D2SW RM	D1SWP UF	D1P UM	C2P RM
E 10	C3SW LM	D2SWP RF	C2SWA RM	C3SWP LM	C2P UM	B2SWP UF
T 11	B3SW(A) LF	D3ASW LM	D2SW UM	C3SW(FB) LM	D2P UG	C3SW(A) LM
E 12	D4P LG	D3SW LF	C3P LM	C3PSW LM	D3SW LG	C3SW LM
R 13	C2SW UF	D2P(SW) RF	C2SW RF	C2SW UF	C3P RG	C2P UF
14	C3FB LF	D2P UF	C3PSW LM	B3SW LM	D2P RG	C3SW LM
15	C3SWPA LF	D3P(SW) RM	C3SW LM	D3SW LM	D3P RG	C3SW LM
16	B4P LG	C3P(SW) LG	D3PSW LG	D3PSW LM	D2P UM	C3ASW LG
17	D3SWS LF	D3P LG	D3SW LM	D2SW RF	D2P LM	C2SW LF

TABLE 6: INTERPRETER OBSERVATIONS OF TIMBER TYPES

WILDHAY RIVER STANDS

	C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B/W 1:15000	
	F5	F6	F9	F10	F13	F14	F1	F2
GROUND	C2FBSW RF	C3SW(FB) LF	C2P RM	C2P RM	C2P RF	D2P RM	D2P UF	C3P RG
1	C3SWP LM	B3SW(P) LF	C2P RF	C2P RF	C2P(SW) LF	D2P RF	C3P RM	C3P LM
2	C3SWP LM	C3SWP LF	C2PSW RM	C2PSW RM	C4SWP LM	D2SBP .UF	C2ASW HM	C2SWP(A) RF
I 3	C3SW(A) LM	B4SW LF	D3P(A) LM	D3PA LM	C3SW RM	D2P RG	D3A(SW) HG	C3SW(A) LM
N 4	C3SW(P) LM	C3SW LF	D2SW(P) RM	C2PSW RM	C3PSW LM	D2SW RM	C2P(SW) RM	C3SW(P) RM
T 5	C3SW(P) RM	B3SWS UF	D3P LG	D3P RG	C3SWP RM	D1P UF	D2P RM	C3SWP LG
E 6	C3SWP LM	C3SW(P) LF	D3P LM	D3PA LM	B3PSW LM	C3P(A) LG	D2P RM	C2PSW LM
R 7	C4SWP LG	C3SW(P) LM	D3P LM	D3P(SW) LM	C3SWP LM	D2SB UM	D2ASW HM	D3SW(A) LG
P 8	C2PSW(A) RM	C3PSW(A) LF	D3PA(SW) LM	D3PSW LG	C2PSW RF	D3P(SW) LG	D3PSW LM	D2PSW(A) RM
R 9	C2SW(P) RF	C2SW RF	D2P RM	D2P RM	C2P(A) RF	D2P RM	D2PSW RM	D2PSW RM
E 10	C3SWA LM	C4SW(A) LG	D3P(A) LG	D2P(A) UM	C3PA(SW) LG	D2PSW UM	C2A(P) UM	C2P(A) UM
T 11	C3SWP LM	B3SW(P) LM	D3P LG	D3P(A) LG	C2SB(FB) UF	D2SB(P) UG	D2P UM	C2PSW RM
E 12	C4SW LM	C4SW LM	C3P LG	D3P(A) LG	C3SWP LM	D3P LG	D3P LG	C3P LM
R 13	C2SWP RF	C3SW(P) LF	D3P(A) RM	D3PA RM	C2P(SW) RM	D2P UM	D2P RM	C2PSW RM
14	B3P(SW) LM	B3SW LF	C3P LG	C3P LG	C3PSW LM	C2P RM	C2P RF	B3SW(P) LM
15	C3SW(P) LM	C4SW LM	D3SW RM	D3SW RM	C3SWP LM	D3SW RM	D2P RM	C3SWP LM
16	C2SB(P) RM	C2SB(P) UF	D2P RG	D2P(A) HM	C3SWA LG	D2P RM	D3P(SB) RG	C3SW(A) LG
17	C3SW LM	B3SW(P) LF	D3SW LM	D3P LM	C2SWP LF	D2SW LM	D3P LG	C3SWP LM

TABLE 7: TWO CREEK: TOTAL SCORES FOR FORESTRY INTERPRETATION

IMAGERY	STAND	(GROUND OATA/NUMBER CORRECT/PERCENT CORRECT)									
		B	2	P	(	A	)			R	M
COLOUR	F12	6	0	14	6	6	6	14	16	3	15
		35	0	82	35	35	35	82	94	18	88
1:30000		C	3	S	B	P	(	S	)	R	G
	F13	13	8	16	4	1	3	0	3	6	1
		77	47	94	24	6	18	0	18	35	6
		C	3	S	W	A				L	M
COLOUR	F1	17	12	14	13	2	11	11	16	12	12
		100	71	82	76	12	65	65	94	71	71
1:50000		C	3	P	A					L	M
	F2	11	12	7	4	9	13	13	15	6	9
		65	71	41	24	53	77	77	88	35	53
		C	4	P	S	W	A			L	G
COLOUR	F15	14	4	10	0	0	0	13	16	14	6
		82	24	59	0	0	0	77	94	82	35
1:70000		C	3	P	S	W	(	A	)	L	M
	F20	8	11	15	1	1	0	0	0	9	11
		47	65	88	6	6	0	0	0	53	65
		C	3	S	W	P	A			L	M
C.I.R.	F10	13	13	17	17	3	3	10	15	16	12
		77	77	100	100	18	18	59	88	94	71
1:30000		C	3	S	W	P	A			L	M
	F11	13	15	17	17	5	7	8	14	16	12
		77	88	100	100	29	41	47	82	94	71
		C	3	A	(	P	)			H	M
C.I.R	F3	10	13	13	1	1	1	13	14	7	14
		59	77	77	6	6	6	77	82	41	82
1:50000		C	4	S	W					L	M
	F4	14	1	17	17	9	12	12	17	12	9
		82	6	100	100	53	71	71	100	71	53
		C	3	S	W	P	A			L	M
C.I.R.	F8	11	14	4	4	2	2	10	11	14	11
		65	82	24	24	12	12	59	65	82	65
1:70000		D	3	P	(	A	)			L	M
	F9	6	14	15	6	4	3	12	15	11	13
		35	82	88	35	24	18	71	88	65	77
		C	3	S	W	P	(	A	)	R	G
B/W	F16	13	13	5	5	2	3	3	4	4	5
		77	77	29	29	12	18	18	24	24	29
1:15000		C	1	S	B					U	F
	F17	11	4	15	10	9	14	14	17	7	10
		65	24	88	59	53	82	82	100	41	59

TABLE 8: CACHE PERCOTTE: FORESTRY INTERPRETATION - TOTAL SCORE TABLE

IMAGERY	STAND	(GROUND OATA / NUMBER CORRECT / PERCENT CORRECT)									
COLOUR 1:30000	F7	B	2	S	B	A				U	G
		10	12	8	3	4	10	10	13	6	3
		59	71	47	18	24	59	59	77	35	18
	F8	C	2	P	(	S	W	)		R	F
		14	1	16	5	4	3	5	16	3	1
		82	6	94	29	24	18	29	94	18	6
COLOUR 1:50000	F13	B	2	A	(	S	W	)		U	M
		1	11	6	2	0	0	1	14	2	11
		6	65	35	12	0	0	6	82	12	65
	F14	B	2	A	(	S	W	)		U	M
		10	5	10	2	3	2	1	15	2	16
		59	29	59	12	18	12	6	88	12	94
COLOUR 1:70000	F16	O	3	P						R	G
		15	14	14	12	14	14	14	17	4	8
		88	82	82	71	82	82	82	100	24	47
	F17	O	3	P						R	G
		11	11	12	9	13	15	15	17	4	8
		65	65	71	53	77	88	88	100	24	47
C.I.R. 1:30000	F1	B	2	S	W	S				R	F
		15	9	14	13	1	7	8	17	7	7
		88	53	82	77	6	41	47	100	41	41
	F9	B	3	P	(	S	W	)		R	M
		0	15	17	6	2	2	2	15	0	12
		0	88	100	35	12	12	12	88	0	71
C.I.R. 1:50000	F6	C	2	A	(	S	W	)		H	F
		16	5	14	7	6	6	5	12	11	1
		94	29	82	41	35	35	29	71	65	6
	F10	C	3	S	W					L	M
		13	12	12	11	1	6	8	14	11	13
		77	71	71	65	6	35	47	82	65	77
C.I.R. 1:70000	F3	C	2	S	W	(	A	)		R	M
		15	4	7	5	3	1	2	11	6	14
		88	24	41	29	18	6	12	65	35	82
	F18	C	2	S	W	(	P	)		R	M
		10	9	15	14	6	3	6	15	7	13
		59	53	88	82	35	18	35	88	41	77
B/W 1:15000	F5	C	3	P	A	(	S	W	)	L	M
		16	15	4	1	8	1	1	4	17	10
		94	88	24	6	47	6	6	24	100	59
	F15	C	2	A	(	S	W	)		H	F
		15	0	15	8	8	8	8	16	12	0
		88	0	88	47	47	47	47	94	71	0

TABLE 9: WILDHAY RIVER: FORESTRY INTERPRETATION - TOTAL SCORE

IMAGERY	STAND	(GROUND DATA / NUMBER CORRECT / PERCENT CORRECT)									
		B	2	S	W	(	F	B	)	R	F
	F3	2	2	13	13	2	0	0	0	1	10
COLOUR		12	12	77	77	12	0	0	0	6	59
1:30000		D	2	P						R	F
	F4	12	6	12	6	8	14	14	17	6	9
		71	35	71	35	47	82	82	100	35	53
		C	3	S	W	P				L	M
	F7	10	11	11	11	1	15	15	17	9	12
COLOUR		59	65	65	65	6	88	88	100	53	71
1:50000		C	3	S	W	F	B			L	M
	F8	10	11	12	12	0	0	16	16	9	12
		59	65	71	71	0	0	94	94	53	71
		D	3	P						R	G
	F11	13	5	14	11	14	16	16	17	8	7
COLOUR		77	29	82	65	82	94	94	100	47	41
1:70000		C	3	P	S	W				L	M
	F12	14	10	4	1	1	14	14	17	11	11
		82	59	24	6	6	82	82	100	65	65
		C	2	F	B	S	W			R	F
	F5	16	4	0	1	1	1	9	16	5	2
C.I.R.		94	24	0	6	6	6	53	94	29	12
1:30000		C	3	S	W	(	F	B	)	L	F
	F6	11	11	16	15	8	0	0	1	14	12
		65	65	94	88	47	0	0	6	82	71
		C	2	P						R	M
	F9	4	5	14	9	11	12	15	16	7	10
C.I.R.		24	29	82	53	65	71	88	94	41	59
1:50000		C	2	P						R	M
	F10	4	6	16	5	9	12	16	17	7	11
		24	35	94	29	53	71	94	100	41	65
		C	2	P						R	F
C.I.R.	F13	16	6	8	0	1	12	13	15	5	5
		94	35	47	0	6	71	77	88	29	29
1:70000		D	2	P						R	M
	F14	15	12	11	8	12	14	15	17	7	9
		88	71	65	47	71	82	88	100	41	53
		D	2	P						U	F
B/W	F1	12	11	13	9	9	13	14	17	2	1
		71	65	77	53	53	77	82	100	12	6
1:15000		C	3	P						R	G
	F2	13	10	8	2	2	9	10	15	6	3
		77	59	47	12	12	53	59	88	35	18

10. Appendix C: Recreation Interpretation

TABLE 1: RECREATION SITE INTERPRETATION: TWO CREEK

		COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000		C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B / W 1:15000	
		R4	R9	R14	R15	R6	R8	R10	R12	R11	R13	R2	R5	R1	R3
GROUND		22312222	21412332	22311266	21531133	13542187	23553188	12531345	22311333	12531354	32542186	24532252	23321133	12311223	22531155
	1	24411146	23531231	42411351	32531122	31551155	23551155	12542147	13412323	15541153	43542181	34412361	41322361	22551165	42552151
I	2	25312242	23631167	32222162	24631156	22551154	12551156	12552253	12412332	15412331	33541162	21531246	24321167	22551264	31541163
N	3	22311152	21511154	33221182	23531166	23541288	23541267	22531232	24311332	12541331	34533171	23531331	33311234	34541266	31531156
T	4	25311372	24531178	35312391	24532168	23553287	25553198	12541372	14411334	15541311	44532361	25531331	33321276	12531311	32532385
E	5	22311146	23531146	12311142	23531137	23542233	23542232	12541343	14311235	12311332	34531142	24542232	21311244	12531323	22531143
R	6	35411322	34531165	45413351	24531166	33553264	35553165	12411332	15411331	15411321	44532161	24531343	35321142	24541354	42542161
P	7	25311222	31541174	21311152	21531262	21541288	21541264	22311352	13411342	15541244	34531183	24531288	21121297	22541375	31541174
R	8	24531235	23531147	33321271	24531137	23553188	24552186	12311264	14531247	15311135	44531171	34541264	21311186	14541278	34541144
E	9	25531234	21631158	34542311	23531256	23551177	25553311	14552331	23412311	25542233	44531182	15541243	23321177	24542242	42541182
T	10	24411364	23631156	43542174	22531157	11533277	11543287	22333255	13411345	11553265	43533164	13543264	21311175	24543274	42533173
O	11	12311211	11531115	12321151	14531125	13541176	13541233	12321321	13411311	12551321	24531131	13531311	11311233	12551351	22531122
R	12	32311132	32531143	42312171	22531127	11531246	22542235	12541331	24311234	15531246	44532171	25311322	25311242	12542333	41542161

TABLE 2: RECREATION SITE INTERPRETATION: CACHE PERCOTTE

		COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000		C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B / W 1:15000	
		R6	R7	R4	R12	R13	R14	R1	R11	R5	R15	R3	R16	R2	R10
GROUND		34532163	32532175	12411331	12412322	22531223	14531244	42531182	23531155	32531243	22531344	42531162	12412342	32532164	44532155
	1	44532252	31531132	22411322	22411312	22511244	32511242	44531162	43532243	34511232	32511133	42532162	14311263	43531135	41532262
I	2	24531232	23411321	25412331	15412221	12541244	22541153	34541152	33543284	34531162	22631175	31531162	15311332	24531166	31541172
N	3	33531155	24531243	24411321	14411321	34531245	23411322	34531167	33531163	34531122	34531122	34531142	24311264	24531166	43532171
T	4	32531275	32532264	25631231	22531234	22532266	32532172	42531163	32532246	34532246	22531144	44532263	22311331	34432254	44532181
E	5	34531134	24531233	11411341	12411331	14531256	22531254	34531154	23531254	32531144	22531144	32531164	12321332	24531135	33542343
R	6	44542162	44541163	22311376	12531255	33531175	43531172	43531263	33531164	34531164	22531155	44541172	24321352	43541164	43543161
P	7	34531177	21531167	15411342	13411344	23531287	24531177	34531186	23531286	24531286	24531235	32531185	12311342	24531287	21541275
R	8	34531255	24531267	12611351	12411311	12531238	22531157	34531145	33533153	34511133	22531135	22531146	14311344	13531138	41543284
E	9	24631335	33631333	22412231	12412221	23531245	34531242	34531275	33531187	24531167	24531164	32531133	12312321	34531267	11531176
T	10	33531145	23531246	14611273	12411253	13533257	33533264	34631156	23533256	24311157	22311146	34533165	13311376	44531157	41542273
O	11	22411111	22411134	12411341	12411212	12531222	22531131	24531144	21531135	24531122	12411222	22421133	12311352	24541124	21541134
R	12	42532122	34531224	12411321	12411312	22531145	42532131	44532151	43532142	34532132	32531123	42532151	12311331	34531143	43533141

TABLE 3: RECREATION SITE INTERPRETATION: WILOHAY RIVER

		COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000		C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B / W 1:15000	
		R3	R4	R7	R8	R11	R12	R5	R6	R9	R10	R13	R14	R1	R2
GROUNO		15411351	14551166	22543184	32543177	15312254	34531144	21542223	13532225	22542275	14553334	32533186	32553273	15552266	42542172
	1	15432381	11551178	32531176	44532273	15552164	43511161	15412363	15541265	23551155	23551255	35541163	44542172	25541253	44542171
I	2	12322231	11553168	32541165	42541163	12551154	42541162	11223152	11543155	33551157	23551144	42541154	32551162	14542162	34541154
N	3	12422361	23551288	22541275	32532264	22411361	43542277	23412271	13412371	23551155	24551287	22412275	34551263	13552213	34412255
T	4	15411311	14551197	22543186	42533184	25551286	44541196	15532391	15541293	13551296	14551188	45541285	44552291	15541356	34542262
E	5	15421261	13541187	22531266	34531254	15543352	34532175	11542351	15542342	23543282	23543264	35542352	44551174	15542344	32541166
R	6	15411331	23551176	34542273	44543171	15552361	44542171	15543351	15553351	13553272	13553262	35552261	44543171	15552331	43552251
P	7	15411352	11541286	14541286	34543153	15551352	33531164	11311355	15541322	13551375	13551287	24541164	24551285	15541352	34543162
R	8	12411284	13543199	34532286	24532187	15543188	44533163	13311371	11543243	13543187	14543285	35533275	34542292	15543184	34542171
E	9	15422311	13541178	12543232	32543122	15532177	44531171	15311223	15541257	23553265	14551244	35541186	44541173	15541277	34541154
T	10	12413374	11543178	24533277	34533254	12543263	33531156	11321275	11541253	11553178	13543167	22543276	34543264	13553252	34553155
O	11	12411351	13531167	12531133	22531132	12551165	23531121	11531165	15531147	13531134	13531155	14531155	24531182	13531134	24531132
R	12	15411351	11531266	12533273	42532165	15533275	42533161	15531371	15531352	13531372	14531332	15531272	42533181	15531372	34532351

TABLE 4: TWO CREEK: RECREATION INTERPRETATION - TOTAL SCORE TABLE

IMAGERY	(GROUND DATA/NUMBER CORRECT/PERCENT CORRECT)							
	2	2	3	1	2	2	2	2
	9	4	7	10	1	5	2	6
COLOUR	75	33	58	83	8	42	17	50
1:30000	2	1	4	1	2	3	3	2
	8	4	0	1	0	0	1	0
	67	33	0	8	0	0	8	0
	2	2	3	1	1	2	6	6
	1	5	6	6	6	1	1	0
COLOUR	8	42	50	50	50	8	8	0
1:50000	2	1	5	3	1	1	3	3
	10	1	11	12	11	10	2	0
	83	8	92	100	92	83	17	0
	1	3	5	4	2	1	8	7
	3	7	12	4	1	5	4	3
COLOUR	25	58	100	33	8	42	33	25
1:70000	2	3	5	5	3	1	8	8
	8	4	12	6	4	5	2	1
	67	33	100	50	33	42	17	8
	1	2	5	3	1	3	4	5
	9	11	7	2	8	7	2	1
C.I.R.	75	92	58	17	67	58	17	8
1:30000	2	2	3	1	1	3	3	3
	3	1	3	11	9	9	6	1
	25	8	25	92	75	75	50	8
	1	2	5	3	1	3	5	4
	11	3	8	1	9	6	1	1
C.I.R.	92	25	67	8	75	50	8	8
1:50000	3	2	5	4	2	1	8	6
	4	0	12	2	4	11	3	0
	33	0	100	17	33	92	25	0
	2	4	5	3	2	2	5	2
C.I.R.	7	5	10	6	2	6	0	2
	58	42	83	50	17	50	0	17
1:70000	2	3	3	2	1	1	3	3
	7	3	11	6	11	5	2	1
	58	25	92	50	92	42	17	8
	1	2	3	1	1	2	2	3
B/W	5	7	0	0	9	5	1	2
	42	58	0	0	75	42	8	17
1:15000	2	2	5	3	1	1	5	5
	2	7	12	5	7	11	2	1
	17	58	100	42	58	92	17	8

TABLE 5:CACHE-PERCOTTE: RECREATION INTERPRETATION - TOTAL SCORE TABLE

IMAGERY	(GROUND DATA/NUMBER CORRECT/PERCENT CORRECT)							
	3	4	5	3	2	1	6	3
	6	7	10	10	3	7	1	0
COLOUR	50	58	83	83	25	58	8	0
1:30000	3	2	5	3	2	1	7	5
	4	2	9	9	1	4	0	0
	33	17	75	75	8	33	0	0
	1	2	4	1	1	3	3	1
	6	6	8	11	10	9	3	8
COLOUR	50	50	67	92	83	75	25	67
1:50000	1	2	4	1	2	3	2	2
	10	9	10	10	2	6	3	3
	83	75	83	83	17	50	25	25
	2	2	5	3	1	2	2	3
	5	6	12	10	10	10	1	0
COLOUR	42	50	100	83	83	83	8	0
1:70000	1	4	5	3	1	2	4	4
	0	2	11	9	9	4	2	2
	0	17	92	75	75	33	17	17
	4	2	5	3	1	1	8	2
	4	1	11	11	11	10	1	2
C.I.R.	33	8	92	92	92	83	8	17
1:30000	2	3	5	3	1	1	5	5
	4	10	12	11	6	6	3	1
	33	83	100	92	50	50	25	8
	3	2	5	3	1	2	4	3
	8	1	11	9	10	3	2	1
C.I.R.	67	8	92	75	83	25	17	8
1:50000	2	2	5	3	1	3	4	4
	8	9	9	9	12	0	3	3
	67	75	75	75	100	0	25	25
	4	2	5	3	1	1	6	2
C.I.R.	4	7	11	10	8	11	5	4
	33	58	92	83	67	92	42	33
1:70000	1	2	4	1	2	3	4	2
	9	6	0	10	1	10	2	5
	75	50	0	83	8	83	17	42
	3	2	5	3	2	1	6	4
B/W	3	0	11	10	1	9	4	3
	25	0	92	83	8	75	33	25
1:15000	4	4	5	3	2	1	5	5
	7	1	12	5	5	7	0	1
	58	8	100	42	42	58	0	8

TABLE 6: WILDHAY RIVER: RECREATION INTERPRETATION - TOTAL SCORE

IMAGERY	(GROUND DATA/NUMBER CORRECT/PERCENT CORRECT)							
	1	5	4	1	1	3	5	1
	12	7	11	7	7	9	3	9
COLOUR	100	58	92	58	58	75	25	75
1:30000	1	4	5	5	1	1	6	6
	10	1	12	5	9	9	3	3
	83	8	100	42	75	75	25	25
	2	2	5	4	3	1	8	4
	4	8	12	6	4	4	3	0
COLOUR	33	67	100	50	33	33	25	0
1:50000	3	2	5	4	3	1	7	7
	5	6	12	4	5	8	2	1
	42	50	100	33	42	67	17	8
	1	5	3	1	2	2	5	4
	10	8	0	1	3	3	3	2
COLOUR	83	67	0	8	25	25	25	17
1:70000	3	4	5	3	1	1	4	4
	3	5	12	7	7	11	0	1
	25	42	100	58	58	92	0	8
	2	1	5	4	2	2	2	3
	1	5	5	2	4	3	1	2
C.I.R.	8	42	42	17	33	25	8	17
1:30000	1	3	5	3	2	2	2	5
	12	1	11	2	2	5	1	2
	100	8	92	17	17	42	8	17
	2	2	5	4	2	2	7	5
	4	0	12	2	0	4	4	4
C.I.R.	33	0	100	17	0	33	33	33
1:50000	1	4	5	5	3	3	3	4
	8	5	12	7	4	1	1	3
	67	42	100	58	33	8	8	25
	3	2	5	3	3	1	8	6
C.I.R.	5	3	11	3	2	5	2	2
	42	25	92	25	17	42	17	17
1:70000	3	2	5	5	3	2	7	3
	4	2	12	5	3	5	4	2
	33	17	100	42	25	42	33	17
	1	5	5	5	2	2	6	6
B/W	11	8	12	3	4	4	1	1
	92	67	100	25	33	33	8	8
1:15000	4	2	5	4	2	1	7	2
	2	1	11	7	6	8	2	3
	17	8	92	58	50	67	17	25

11. Appendix D: Wildlife Habitat Interpretation

TABLE 1: WILDLIFE HABITAT INTERPRETATION: TWO CREEK

		COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000		C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B / W 1:15000	
		W2	W11	W3	W16	W7	W8	W9	W10	W12	W4	W1	W13	W14	W15
GROUND		08A3133	11P2133	07S2122	11S1135	11S3132	08A2133	10S3123	08A3133	11P3133	08A2133	01NO114	07S2122	07P1133	11P2132
	1	10S3120	08A1120	08A1125	08A2110	11S2122	10S2125	08A2110	09A2110	10P1130	09A2125	01P2134	11S1125	08A1125	08A1113
I	2	09A3113	08A2113	04W1122	04W1133	07S2122	05W1122	10A3113	08A3113	11P2133	08A2135	01A0134	04W1122	03S1122	09A3113
N	3	10P3133	09P2133	04W1123	04W1135	07S2122	05NO132	11P3133	10P3113	11P2135	08A2123	01NO134	07S2122	04W2122	10P2125
T	4	09S2123	0701122	0301123	0401113	0701122	0101132	08A2213	11S3123	02S1124	08A2115	01A2134	0401123	04W1122	11W1122
E	5	09A2133	08A1112	07S1122	0401122	07S2132	0401112	08A2113	10W2135	11P1132	08W1122	01NO135	07S1122	04S1122	04S2122
R	6	09A3123	11P2123	07S2122	11P1133	04W1122	08A2133	10P2213	08A2133	11P2133	08A1123	01NO234	04W1122	04W1122	08A2125
P	7	08A3113	07S2123	0681122	05N1122	03S2233	02W1133	09A2113	09A3135	04W1122	0301125	01NO135	05NO122	04W2122	03W2122

TABLE 2: WILDLIFE HABITAT INTERPRETATION: CACHE PERCOTTE

		COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000		C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B / W 1:15000	
		W2	W11	W3	W16	W7	W8	W9	W10	W12	W4	W1	W13	W14	W15
GROUND		08A2134	04W1124	08A1114	11S3122	11S2122	01NO114	08A2134	11W1124	08A1114	0201114	11S3122	11S3122	09A2134	08A2134
	1	09A2134	02P1134	02A1114	11S2130	09A3120	01A1234	03A2114	09A2134	04A1134	04A1134	11P2115	10A1114	08A2134	04A1134
I	2	02A3134	09A3134	04W1114	07S1122	07S2122	01NO233	03W2134	08A2134	04W1134	01NO134	11S2132	04W1122	09A2134	03W1134
N	3	09A3125	09A2124	04A2114	07S2132	07S2122	11P1214	03A1110	08A2134	04A1234	04A1234	07S2122	07S2122	04A2130	03A2134
T	4	1002134	04S2134	04S1134	11S2133	11S2133	0101235	08A2134	08A2134	04A1134	0101134	11S1133	05W1122	0402123	01S1124
E	5	11P2134	11S2114	0401134	07S1122	11S1132	01NO131	08A1134	09A1134	01NO234	01A0132	07S1122	10A1135	09A2114	08A2134
R	6	04W1135	04B1135	04W1215	11P2134	11P2133	02W1135	03A1134	09A1135	04W1234	02W1134	11P3133	07S2132	09A2133	09A2134
P	7	0302134	10S2122	0201213	11S3122	04W1122	01NO234	0401134	0201134	0301233	0401133	04W1112	02W1122	0401135	0401114

TABLE 3: WILDLIFE HABITAT INTERPRETATION: WILDHAY RIVER

		COLOUR 1:30000		COLOUR 1:50000		COLOUR 1:70000		C.I.R. 1:30000		C.I.R. 1:50000		C.I.R. 1:70000		B / W 1:15000	
		W12	W14	W27	W30	W7	W29	W3	W4	W1	W6	W18	W21	W8	W9
GROUND		08A3113	01NO124	03W1125	07S1122	01A1125	06B1123	06W1123	08A3113	07S2122	07L1122	0101124	04W1122	03W1125	04W1122
	1	08A2210	02S2122	01A1122	09A2115	10A1114	01A1114	02S2124	08A2110	02P1114	06S1122	08A2122	02S1122	01A1124	02A1124
I	2	08A2113	01S1122	01A1125	04W1134	11S1114	01NO115	05S3122	08A3113	04W1112	05B1122	03S1122	03A1122	02B1122	02B1122
N	3	08A3213	04W1122	03W1123	04W2133	11P1114	04W1122	04S2122	09A3213	07S2122	07S2122	04W2122	06W1122	01W1123	04W1122
T	4	08A2213	07S2122	0102123	0401123	01S1115	0101123	01S2123	08A3213	0201113	0501122	02W1123	07W1122	0102123	01P3123
E	5	02NO213	07S2122	04P1122	11P1113	11P1135	0201112	04P1122	08A3213	02NO113	07S1122	0401122	02P1122	06NO122	07S2122
R	6	08A3213	06SO122	01NO123	06NO122	01NO135	01NO133	01NO123	08A3213	06S1122	04W1122	04W1122	06SO122	04W1122	04W1122
P	7	01NO213	03W1115	01NO122	04W2122	0301114	02W1122	07S3122	11F3213	07S2123	01NO122	08A2112	05NO122	0301122	03W1133

TABLE 4: TWO CREEK: WILDLIFE HABITAT INTERPRETATION - TOTAL SCORE TABLE

IMAGERY	(GROUND DATA/NUMBER CORRECT/PERCENT CORRECT)						
	0	8	A	3	1	3	3
	5	1	4	5	7	2	6
COLOUR	71	14	57	71	100	29	86
1:30000	1	1	P	2	1	3	3
	1	1	2	4	7	1	4
	14	14	29	57	100	14	57
	0	7	S	2	1	2	2
	7	2	2	1	7	7	4
COLOUR	100	29	29	14	100	100	57
1:50000	1	1	S	1	1	3	5
	1	1	0	6	7	3	1
	14	14	0	86	100	43	14
	1	1	S	3	1	3	2
	1	1	5	0	6	2	6
COLOUR	14	14	71	0	86	29	86
1:70000	0	8	A	2	1	3	3
	6	1	1	2	7	4	2
	86	14	14	29	100	57	29
	1	0	S	3	1	2	3
	3	2	0	2	5	0	6
C.I.R.	43	29	0	29	71	0	86
1:30000	0	8	A	3	1	3	3
	4	2	4	4	7	3	4
	57	29	57	57	100	43	57
	1	1	P	3	1	3	3
	5	4	5	0	7	5	2
C.I.R.	71	57	71	0	100	71	29
1:50000	0	8	A	2	1	3	3
	7	5	5	4	7	1	2
	100	71	71	57	100	14	29
	0	1	N	0	1	1	4
C.I.R.	7	7	4	5	6	0	5
	100	100	57	71	86	0	71
1:70000							
	0	7	S	2	1	2	2
	6	2	3	1	7	7	5
	86	29	43	14	100	100	71
	0	7	P	1	1	3	3
B/W	7	0	0	5	7	0	0
	100	0	0	71	100	0	0
1:15000							
	1	1	P	2	1	3	2
	2	1	1	4	7	0	3
	29	14	14	57	100	0	43

TABLE 5: CACHE PERCOTTE: WILDLIFE HABITAT INTERPRETATION - TOTAL SCORE TABLE

IMAGERY	(GROUND DATA/NUMBER CORRECT/PERCENT CORRECT)						
	0	8	A	2	1	3	4
	5	0	3	4	7	6	5
COLOUR	71	0	43	57	100	86	71
1:30000	0	4	W	1	1	2	4
	5	2	0	2	7	2	5
	71	29	0	29	100	29	71
	0	8	A	1	1	1	4
	7	0	2	6	5	5	5
COLOUR	100	0	29	86	71	71	71
1:50000	1	1	S	3	1	2	2
	4	4	6	1	7	3	4
	57	57	86	14	100	43	57
	1	1	S	2	1	2	2
	3	3	4	4	7	5	4
COLOUR	43	43	57	57	100	71	57
1:70000	0	1	N	0	1	1	4
	6	6	3	3	2	1	3
	86	86	43	43	29	14	43
	0	8	A	2	1	3	4
	7	2	5	3	7	5	6
C.I.R.	100	29	71	43	100	71	86
1:30000	1	1	W	1	1	2	4
	0	0	0	3	7	0	6
	0	0	0	43	100	0	86
	0	8	A	1	1	1	4
	7	0	3	6	3	0	6
C.I.R.	100	0	43	86	43	0	86
1:50000	0	2	D	1	1	1	4
	7	1	2	5	6	0	5
	100	14	29	71	86	0	71
	1	1	S	3	1	2	2
C.I.R.	4	4	4	1	7	2	4
	57	57	57	14	100	29	57
1:70000	1	1	S	3	1	2	2
	2	0	2	0	7	4	5
	29	0	29	0	100	57	71
	0	9	A	2	1	3	4
B/W	7	3	5	6	7	5	3
	100	43	71	86	100	71	43
1:15000	0	8	A	2	1	3	4
	7	1	4	3	7	5	7
	100	14	57	43	100	71	100

TABLE 6: WILDHAY RIVER: WILDLIFE HABITAT INTERPRETATION - TOTAL SCORE

IMAGERY	(GROUND DATA/NUMBER CORRECT/PERCENT CORRECT)					
	0	8	A	3	1	1	3
	7	5	5	2	1	7	6
COLOUR	100	71	71	29	14	100	86
1:30000	0	1	N	0	1	2	4
	7	1	0	1	7	6	0
	100	14	0	14	100	86	0
	0	3	W	1	1	2	5
	7	1	1	4	7	7	1
COLOUR	100	14	14	57	100	100	14
1:50000	0	7	S	1	1	2	2
	6	0	0	3	7	3	2
	86	0	0	43	100	43	29
	0	1	A	1	1	2	5
	3	5	1	6	7	0	3
COLOUR	43	71	14	86	100	0	43
1:70000	0	6	B	1	1	2	3
	7	0	0	5	7	3	2
	100	0	0	71	100	43	29
	0	6	W	1	1	2	3
	7	0	0	1	7	7	2
C.I.R.	100	0	0	14	100	100	29
1:30000	0	8	A	3	1	1	3
	6	5	6	6	2	7	6
	86	71	86	86	29	100	86
	0	7	S	2	1	2	2
	7	2	3	2	7	3	3
C.I.R.	100	29	43	29	100	43	43
1:50000	0	7	L	1	1	2	2
	7	2	0	5	7	7	7
	100	29	0	71	100	100	100
	0	1	O	1	1	2	4
C.I.R.	7	0	1	4	7	6	0
	100	0	14	57	100	86	0
1:70000							
	0	4	W	1	1	2	2
	7	0	2	5	7	7	7
	100	0	29	71	100	100	100
	0	3	W	1	1	2	5
B/W	7	1	2	5	7	7	0
	100	14	29	71	100	100	0
1:15000							
	0	4	W	1	1	2	2
	7	2	3	5	7	6	4
	100	29	43	71	100	86	57

12. Appendix E: Interpretation Time Required

TABLE 1: TIMES REQUIRED FOR FORESTRY INTERPRETATION

I	TWO CREEK							CACHE - PERCOTTE							WILDHAY RIVER						
	COLOR			C.I.R.			B&W	COLOR			C.I.R.			B&W	COLOR			C.I.R.			B&W
	1:30	1:50	1:70	1:30	1:50	1:70	1:15	1:30	1:50	1:70	1:30	1:50	1:70	1:15	1:30	1:50	1:70	1:30	1:50	1:70	1:15
1	1.5	1.17	1.58	1.25	1.58	1.5	1.67	1.83	2.17	1.33	1.25	1	1.5	1.75	2	1.5	0.83	1.25	1	1.25	1.42
2	3.83	2.33	2.75	3.58	2.92	1.67	2.92	1.5	2.75	1.25	2.25	2.33	2.42	2.83	3.75	4.17	3.58	3.08	2.08	3	4.5
3	2	2.33	2.33	1.83	2.25	1.58	3.25	1.5	1.67	1.83	1.75	2.17	1.67	2.5	1.58	1.25	1.33	1.5	1.25	1.58	1.83
4	5.25	4.33	1.5	3.17	3.33	2.67	5.67	2.25	4.5	2.5	1.25	1.58	3.58	3	2.58	2.5	3	2.25	1.58	2.83	3
5	1.17	1.5	1.17	1.42	1.5	1.25	1.5	1.08	1.5	1.25	1.67	1.17	1.67	1.5	1.42	0.83	1.17	1.08	1.25	1.33	1.33
6	2	2.25	2.5	1.58	1.83	1.33	4.83	2.5	3.08	2.25	2.17	2	2.83	6.33	3.42	2.75	2.5	4.17	2.08	3.17	3.1
7	1.5	1.67	1.25	1.25	2.33	1.5	1.58	1.08	1.5	1	1.42	1.33	1	0.83	1.17	0.92	0.75	0.83	0.83	2.33	1.5
8	2.17	1.92	1.17	1.17	1.25	1.33	1.83	1.5	1.83	1.08	1.5	2.08	1.92	1.33	1.17	0.83	1.17	2.25	1.33	1.5	1
9	0.83	1.67	2.33	1.92	1.67	1	1.67	1.58	2	1.08	1.42	1	1.08	0.75	1.08	0.83	1	1.08	0.58	1.17	1.17
10	1.25	0.92	2.75	2	2.42	1.92	1.17	1.75	2	1	1.67	2.25	1.42	1.42	2.25	2.17	2	1.5	1.92	2	1.33
11	1.33	1.25	1.17	0.83	1.42	1.75	1.67	1.83	1.58	1.17	1.5	1.42	1.75	1.08	1.08	1.17	1.33	1.25	1	1.25	1.5
12	1.67	1	1.42	1	1.25	2.25	2.58	1.33	1.83	1.33	1.67	1.92	2.58	1.75	1.83	2.25	2.33	2.33	2.83	1.42	1.5
13	1.75	1.33	1.17	1.08	1.08	0.92	1.5	0.92	1.25	1.17	1.08	1.58	1.42	1.58	1.25	1	1.42	1	0.83	1.25	1
14	1.17	2.5	2.5	1	1	1.17	2.33	2.92	1.75	1.75	1.5	1.5	2.33	1.67	3.92	3.5	2.5	2.92	1.67	1.75	3
15	1.83	1.67	1.33	1.42	1.58	1.5	1.75	1.83	3.25	1.08	1.25	1.5	1.5	1.75	1.75	1.08	0.83	0.92	1	1.25	1.42
16	2.17	1.67	2.67	0.75	1.17	2.17	1.42	2.5	2	1.33	1.33	1.92	1.67	1.5	1.5	2.25	2.75	1.33	2.67	2	3.17
17	1.75	2.42	1.25	1.17	2	1.08	1.17	2.92	2.08	1	1.67	1.83	2.5	1.42	1.75	1.67	1.83	1.83	1.08	1.33	1.75

TABLE 2: TIMES REQUIRED FOR RECREATON INTERPRETATION

I	TWO CREEK							CACHE-PERCOTTE							WILDHAY RIVER						
N	COLOR			C.I.R.			B&W	COLOR			C.I.R.			B&W	COLOR			C.I.R.			B&W
T	1:30	1:50	1:70	1:30	1:50	1:70	1:15	1:30	1:50	1:70	1:30	1:50	1:70	1:15	1:30	1:50	1:70	1:30	1:50	1:70	1:15
1	3.92	5.5	2.67	4.42	3.83	2.92	3.17	3.58	2.83	2.33	2.5	3	3.25	2.42	3.25	2.75	2.83	3	3.08	3.5	2.25
2	3.08	1.83	2.08	1.83	1.58	2.25	2.42	1.92	2.58	1.83	3.75	1.67	2.5	2	1.25	1.58	1.08	1.92	1.58	1.5	1.42
3	3	4.5	2.17	5.33	4.17	3.67	3.33	3.5	1.83	2.33	1.17	2.83	3.17	2.75	2	2.92	2.83	2	2.5	2.17	3.17
4	2.08	2.08	2.67	2.5	1.83	2.83	2.25	2.83	3	3.17	2.83	3.67	2.5	3.17	2.33	1.67	2.67	2.17	2.42	2.42	3.08
5	3.67	4.33	4.83	4.58	3.83	4.67	3.92	5	2.08	3.17	2.83	4.17	2.83	3.42	4.08	7.08	4.17	3.75	6.08	5.5	4.42
6	2.5	2.5	3	2.33	1.67	4.25	3.17	3	3.25	3.33	4.17	2.17	2.75	1.92	4.17	2.33	2.17	2.5	1.83	2.67	2.25
7	4.92	5.5	4.75	7.08	5	6.67	5.58	6.5	8.17	4.83	6.5	7.67	5	5.58	3.5	6	2.83	4.83	5.5	6.58	5.33
8	5.83	4.08	4.92	4.67	4	6.08	5.17	5.17	6.5	6.5	6.5	5	6.58	6.17	4.5	3.92	2.92	3.25	3.25	4.17	3.17
9	3.87	4.33	3.08	3.25	2.92	3.67	3.5	4.17	3	3.08	2.67	4	4.08	3.58	3.17	5.58	4.83	4	5.83	3.58	4.25
10	2.5	2.08	2.67	2.58	2	4.67	1.92	1.33	1.75	1.92	1.67	1.33	1.5	1.67	2.08	1.42	1.33	1.75	1.08	2.67	1.58
11	2.25	2.92	3.92	2.42	2	2.25	1.83	4.5	1.58	2.58	2.33	4	4.25	3.83	2.67	3.08	2.67	3.42	1.75	2.25	2
12	1.67	1.5	2.5	2	1.67	2.5	3.17	2	2.17	2.25	1.58	1.67	1.25	1.67	2.17	3.92	1.75	1.92	1.67	2.58	2.75

TABLE 3: TIMES REQUIREO FOR WILDLIFE HABITAT INTERPRETATION

INT	TWO CREEK COLOR 1:30	TWO CREEK COLOR 1:50	TWO CREEK COLOR 1:70	TWO CREEK C.I.R. 1:30	TWO CREEK C.I.R. 1:50	TWO CREEK C.I.R. 1:70	TWO CREEK B&W 1:15	CACHE-PERCOTTE COLOR 1:30	CACHE-PERCOTTE COLOR 1:50	CACHE-PERCOTTE COLOR 1:70	CACHE-PERCOTTE C.I.R 1:30	CACHE-PERCOTTE C.I.R 1:50	CACHE-PERCOTTE C.I.R 1:70	CACHE-PERCOTTE B&W 1:15	WILDHAY RIVER COLOR 1:30	WILDHAY RIVER COLOR 1:50	WILDHAY RIVER COLOR 1:70	WILDHAY RIVER C.I.R 1:30	WILDHAY RIVER C.I.R 1:50	WILDHAY RIVER C.I.R 1:70	WILDHAY RIVER B&W 1:15
1	3.5	3.17	6.83	1.75	3.67	3.42	4.08	1.67	1.92	2	2.92	1.5	1.92	1.5	1.25	1.42	1.83	1.5	1	1	1.5
2	3.5	1.75	2.83	2.92	1.67	1.17	2.33	1.83	1.58	1.17	2.58	1.83	2.67	3.17	2.83	4.58	3.92	2.58	2.58	2.08	1.58
3	8.33	4.17	1.92	4.83	4	3.5	5.5	4.75	7.33	4.83	8.92	2.83	3.67	7.25	3.5	5	4	3.67	1.67	3.83	2.5
4	2.75	2.5	5.25	4.67	5.33	4.08	7.17	5	2.92	3	2.25	1.92	3.17	3.5	2.08	3.33	5.17	2.25	2.67	2.42	4.08
5	2.75	1.17	1.92	2.67	2.67	1.75	1.67	2.17	3.17	2.75	2.75	1.83	2.08	1.83	2.42	1.42	2.33	1.83	1.5	1.92	1.83
6	3.33	3.08	5.33	3.5	2.08	3.67	3.25	3	2.58	2.42	2.33	3.08	2.25	3.08	1.33	2.75	2.92	1.67	2.33	2.17	2
7	7.17	5.08	4.92	7.33	7.5	5.08	4.58	7.33	6.42	7.25	9.67	6.42	8.83	7.25	4.67	3.58	3.83	3.25	3.75	4.67	5.33

13. Appendix F: Munsell-Farnsworth 100 Hue Test

TABLE 1: FARNSWORTH-MUNSELL 100-HUE TEST ERROR SCORES

		TEST 1	TEST 2	MEAN ERROR
	W 1	20.0	29.0	24.5
	W 2	37.0	35.0	36.0
	W 3	34.0	52.0	43.0
	W 4	56.0	73.0	64.5
	W 5	63.0	57.0	60.0
	W 6	39.0	8.0	23.5
	W 7	79.0	67.0	73.0
	R 1	74.0	104.0	89.0
	R 2	49.0	68.0	58.5
	R 3	123.0	184.0	153.5
	R 4	92.0	80.0	86.0
	R 5	49.0	8.0	28.5
I	R 6	55.0	18.0	36.5
N	R 7	24.0	39.0	31.5
T	R 8	84.0	52.0	68.0
E	R 9	47.0	32.0	39.5
R	R10	80.0	59.0	69.5
P	R11	58.0	32.0	45.0
R	R12	55.0	43.0	49.0
E	F 1	22.0	43.0	32.5
T	F 2	23.0	11.0	17.0
E	F 3	49.0	64.0	56.5
R	F 4	80.0	65.0	72.5
	F 5	66.0	71.0	68.5
	F 6	52.0	98.0	75.0
	F 7	100.0	88.0	94.0
	F 8	8.0	8.0	8.0
	F 9	47.0	12.0	29.5
	F10	85.0	59.0	72.0
	F11	3.0	13.0	8.0
	F12	99.0	70.0	84.5
	F13	46.0	70.0	58.0
	F14	42.0	38.0	40.0
	F15	22.0	19.0	20.5
	F16	31.0	12.0	21.5
	F17	46.0	43.0	44.5

14. Appendix G: Forestry Point Interpretation

14.1 Introduction

A preliminary study was conducted during the winter of 1979-1980 involving the identification of the forest stand overstory characteristics of density, height and species composition on the small scale natural color and color infrared photography. Large scale black and white infrared was not included as a treatment. Twenty-one experienced photo-interpreters from the Phase III forest inventory section of the Resource Evaluation and Planning Division participated in the interpretation sessions.

A different approach from the main study was taken to evaluate the suitability of the acquired color imagery for forest inventory. Objectives remained the same:

1. To evaluate the effects of film type and scale on the accuracy of interpretation.
2. To examine the cost effectiveness of the acquired imagery for inventory on the basis of time required for interpretation.

14.2 Experimental Methods

A controlled experiment was conducted to test the significance of film type, scale and interpreter color discrimination ability on the accuracy of interpretation. This design was superimposed over a random block layout.

Factors in this fixed effects model were:

1. Film Type: Natural color and color infrared.
2. Scale: 1:30,000, 1:50,000, 1:70,000.
3. Color discrimination ability.

Hypotheses formulated to indicate film, scale and color discrimination effects were:

1. Interpretation accuracy/time is not related to film type.
2. Interpretation accuracy/time is not related to scale.
3. Interpretation accuracy/time is not related to interpreter color discrimination ability.

Treatment combinations (film/scale) were applied at random within each of the three blocks (see Chapter 2.4: Study Areas for a description of the forest regions). Two sample points were independently assigned to each of the six film/scale combinations. Random coordinates on a grid laid over a base map of each area identified twelve points falling in stocked productive forest land. Points were grouped in closest pairs and assigned at random to each film/scale combination. Point locations were transferred to the natural color and color infrared transparencies using a Bausch and Lomb zoom transfer scope and marked by a small (one millimeter) diameter white circle.

Interpretation sessions were conducted at the Alberta Remote Sensing Center on the Interpretscope. Prior to the sessions, the participants were introduced to the objectives, scope and procedures of the project followed by basic instruction on the interpretation of natural color and color infrared photography. Training photos, with example forest stands identified on the various film/scale combinations, were left for the interpreters to inspect before the session. Participants were tested for color blindness (Ishihara Pseudoisochromatic Color Blindness Test) and color discrimination (Farnsworth-Munsell 100 Hue Test). Following an explanation of the operation of the Interpretscope, film/scale combinations by area were presented to the interpreter in random order. Information regarding scale and direction of view were provided. Time taken for the delineation of the stand in which the point fell, and subsequent stand identification observation, was recorded once the interpreter was comfortably in stereo, was oriented and had located the sample points. Delineation of the stand boundary was done on a transparent overlay with a drafting pen. Experimental controls outlined in Chapter 2.10 were applied. On completion of the interpretation, the participant was asked to fill out a questionnaire indicating personal preferences for film/scale combinations.

A field survey, undertaken during July-August 1980, provided data to confirm or correct the Phase III stand interpretation. Five point sample plots (BAF 3 and BAF 5)

were located at the selected point site, one at the estimated point center, and the remaining four in quadrants 70 meters distant from the center plot. Trees were tallied by species and diameter class. Heights were measured of the four closest dominant/codominant trees to the plot center. Cruise data compilation provided estimates of average stand height, with 95 percent confidence limits, and species composition based on basal area per hectare. Stand density, interpreted on large scale black and white infrared by the Phase III inventory section, was accepted as accurate. As well, stand boundaries delineated on the original Phase III interpretation were accepted for the study areas in Two Creek and Cache Percotte.

Accuracy response, similar to the main study, was the statistic generated by the direct comparison of the interpreters' observations with the ground control. Accuracy score per cell was the average of two trials per block/film/scale combination. Cell scores were grouped and compiled by color discrimination error score by interpreter. Equal sample size groups were maintained by the following division of total error scores (one trial):

Group 1: 0-36

Group 2: 37-66

Group 3: 67 plus.

Session observations were compiled in matrices by sample point within each film/scale/block and interpreter combination. Each response cell, the observations of two

points per film/scale, was assigned a value of 1, 0.5 or 0 in relation to whether both, only one or neither observations matched the ground control. Calculation of percent correct was based on the success rate of each interpreter/film/scale combination. Analysis of the data involved a factorial analysis of variance on the untransformed percentage data. Tukey multiple comparisons were employed to test for significant differences in interpretation accuracy.

Accuracy of stand boundary delineation was evaluated only on the 1:30,000 scale photography for Areas 1 and 2. Area 3 was excluded due to the difficulty of accurate transfer in rugged terrain where ground control was limited. Smaller scales were ignored due to time constraints, and the wide disparity in transfer scales. Individual interpreter delineations were transferred from the acetate overlay to a 1:15,000 base map, superimposed over the accepted boundary position. A graphics calculator was used to measure three areas on each overlay:

1. Total area of the accepted stand.
2. Area common to both the interpreted and accepted stand.
3. Area committed by the interpreter.

The test statistic generated had a distribution from positive one to negative infinity and was calculated as:

$$TS = \frac{\text{common area}}{\text{total area}} - \frac{\text{committed area}}{\text{total area}}$$

Values close to +1 indicated high concurrence and low commission error, which is desirable. Negative values indicated commission errors equal to, or greater than, area in common and were assigned a value of zero. Two factor analysis of variance with replications was used to test for differences in treatment means of the untransformed data.

14.3 Results

A summary of identification accuracy and interpretation time for each film/scale combination by stand characteristic is presented . Treatment effects on imagery performance were analyzed in a 2X3X3 factorial experiment superimposed over a randomized block layout. Table 1 presents a simplified summary of the individual analyses of variance.

Table 1 : Analysis of Variance Summary for Natural Color and Color Infrared Photography

Variable	Factors		
	Film	Scale	Color Discrimination
Density			
Height			*
Species			
Time	*	*	*

Note: The asterisk indicates a significant variance ratio at the 95 percent level.

Film type and scale did not influence the interpretation accuracy of density, height or species composition. Time required for interpretation was significantly more on the natural color (4.39 minutes) than on the color infrared (3.81 minutes) across all scales and interpreter color groups. Also, more time was taken on the 1:30,000 photography (4.48 minutes) than either the 1:50,000 (4.06 minutes) or the 1:70,000 (3.76 minutes) scales. Color perception had no effect on the identification of either density or species, but did significantly influence the interpretation accuracy of stand height and the time required for interpretation and stand delineation. Participants with low error scores had more trouble with height estimates than those with higher error scores. and also took more time as summarized in Table 2.

Table 2 : Tukey Multiple Comparison Results of Color Discrimination Contrasts for A: Height Interpretation Accuracy B: Interpretation Time

A:Height	Percent Correct	B: Time	Minutes
Group 1	36.5	Group 1	4.72
Group 2	53.6	Group 2	3.63
Group 3	55.6	Group 3	3.94

Analysis of the test statistics calculated for stand delineation indicated that the main effect of film type had a significant effect on interpretation accuracy. Greater agreement with the accepted position of stand boundary was evident with the color infrared than with the natural color photography over the limited number of stands examined.

14.4 Discussion and Conclusions

Choice of natural color or color infrared, or the scale of photography, was not found critical for the identification of the forest stand characteristics examined. Interpretation accuracy of density and height were equivalent to scores observed in the main study. Description of species composition was evidently influenced by the manner in which the stands were delineated. Inspection of completed stand delineations around the sample points revealed that no boundary was located identically. As a result, interpreters were examining species composition for

different ground locations. This did not affect observations of primary species, but did influence interpretation of the minor stand components.

Color discrimination ability played a confusing part in the identification of height and time required for interpretation. Better color perception resulted in poorer height estimation. Also, more time was taken by interpreters with lower discrimination scores. Three explanations for these results are suggested:

1. One trial of the Farnsworth-Munsell 100 Hue Test was inadequate to establish color discrimination ability.
2. Class limits for the discrimination classes were inappropriate.
3. Experimental procedures, such as the requirement that the interpreter delineate the forest stand prior to density, height and species identification, confused the individual results.

Analysis of stand boundary delineation was based on estimates of omitted and committed areas. Boundary location on the color infrared was more "accurate" than the color infrared across all interpreters, but this might have been influenced by the stands selected for each film. Stands were not of the same size nor structure (density, height, species). Generally, however, participants had less trouble outlining the types on the color infrared imagery.

TABLE 3: INTERPRETATION PERFORMANCE BY FILM TYPE AND SCALE

FILM TYPE	NATURAL COLOR			COLOR INFRARED		
SCALE	1:30,000	1:50,000	1:70,000	1:30,000	1:50,000	1:70,000
PERCENT CORRECT						
DENSITY	53.2	51.6	48.4	56.3	59.5	50.0
HEIGHT	49.2	51.6	48.4	44.4	48.4	49.2
TOTAL SPECIES	24.6	19.1	19.1	27.8	17.5	21.4
TIME (MINUTES)	5.06	4.38	3.73	3.90	3.73	3.78